AD-775 300

AERODYNAMICS OF GUIDED AND UNGUIDED WEAPONS PART II. COMPUTER PROGRAM AND USAGE

Frank G. Moore, et al

Naval Weapons Laboratory
Dahlgren, Virginia

January 1974

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER TR-3036	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER AD 775300
4. TITLE (and Subtitle) AERODYNAMICS OF GUIDED AND UNGUIDED WEAPONS PART II COMPUTER PROGRAM AND USAGE		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Frank G. Moore C. William McKerley		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Weapons Laboratory Dahlgren, Va. 22448		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE January 1974
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes a computer program for calculating static forces and moments on canard-body-tail configurations. The program is applicable in the Mach number range, $0 \leq M_\infty \leq 3$, and angle of attack range, $0 \leq \alpha < 20°$. The theoretical development of the methods used in the program is given in Part I of the report; however, for reference purposes, the various theories used are listed herein.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

A detailed description of the program usage, including input and output quantities, is also given.

Several example cases are considered and the calculated aerodynamics compared with experimental data. In general, accuracies of ±10% can be expected for normal force and drag and the center of pressure is expected to be accurate to within ± 8% of the body length. It costs less than $8.00 per Mach number or angle of attack (on the CDC 6700 Computer) to calculate the static aerodynamics of a typical configuration.

NWL Technical Report No. TR-3036
January 1974

AERODYNAMICS OF GUIDED AND UNGUIDED WEAPONS

PART II – COMPUTER PROGRAM AND USAGE

by

Frank G. Moore
C. William McKerley

Surface Warfare Department

D D C

Approved for public release; distribution unlimited.

ib

FOREWORD

This work was performed to provide a design tool for use in estimating the aerodynamics of guided and unguided projectiles. Support for the work was provided by the Naval Ordnance Systems Command under ORDTASK 35A-501/090-1/UF 32-323-505.

This report was reviewed and approved by Mr. D. A. Jones, III, Head of the Aeroballistics Group and by Mr. C. A. Cooper, Head of the Guided Projectile Division.

Released by:

R. L. Topping

R. L. TOPPING, CDR, USN
Assistant Head, Surface Warfare Department

CONTENTS

LIST OF FIGURES

I. INTRODUCTION

The goal of the present research is to develop the capability to compute static aerodynamics on configurations such as guided and unguided projectiles for the Mach number range zero to three and angle of attack range zero to about twenty degrees. The Mach number and angle of attack range cover present and probable future design requirements for gun-launched weapons.

Included in the present report is a detailed description of the computer program, along with several example cases and a FORTRAN listing of the program. For the derivation and discussion of the various theoretical methods used in the development of the prediction program, the reader is referred to Part I of this report (Reference 1). However, for information purposes, the methods used to compute the particular force or moment component in the given Mach number region are listed in Figures 1 and 2. Figure 1 gives the methods for the body alone and Figure 2 those for the tail (or canard) alone along with the interference effects. Most of the methods listed are standard in the literature with the exception of the empirical methods and the combined Newtonian Perturbation theories. Detailed discussion of this new theoretical method for calculating body wave drag can be found in Reference 2 and for wing wave drag in Reference 1.

COMPONENT \ MACH NUMBER REGION	SUBSONIC	TRANSONIC	SUPERSONIC
NOSE WAVE DRAG	—	Wu and AOYOMA PLUS EMPIRICAL	2^{nd} ORDER VAN DYKE PLUS MODIFIED NEWTONIAN
BOATTAIL WAVE DRAG	—	Wu and AOYOMA	2^{nd} ORDER VAN DYKE
SKIN FRICTION DRAG	VAN DRIEST II		
BASE DRAG	EMPIRICAL		
INVISCID LIFT and PITCHING MOMENT	EMPIRICAL	Wu and AOYOMA PLUS EMPIRICAL	TSIEN 1^{st} ORDER CROSSFLOW
VISCOUS LIFT and PITCHING MOMENT	ALLEN and PERKINS CROSSFLOW		

FIGURE 1

Methods Used to Compute Body Alone Aerodynamics

COMPONENT \ MACH NUMBER REGION	SUBSONIC	TRANSONIC	SUPERSONIC
INVISCID LIFT AND PITCHING MOMENT	LIFTING SURFACE THEORY	EMPIRICAL	LINEAR THEORY
WING-BODY INTERFERENCE	SLENDER BODY THEORY AND EMPIRICAL		LINEAR THEORY, SLENDER BODY THEORY & EMPIRICAL
WING-TAIL INTERFERENCE	LINE VORTEX THEORY		
WAVE DRAG	—	EMPIRICAL	LINEAR THEORY + MODIFIED NEWTONIAN
SKIN FRICTION DRAG	VAN DRIEST		
TRAILING EDGE SEPARATION DRAG	EMPIRICAL		
BODY BASE PRESSURE DRAG CAUSED BY TAIL FINS	EMPIRICAL		

FIGURE 2

Methods Used to Compute Wing Alone and Interference Aerodynamics

II. PROGRAM DESCRIPTION

A. Configuration Geometry

The program is designed for four possible configurations: (1) wing alone, (2) body alone, (3) wing-body, and (4) canard-body-tail. Note that in present terminology, wing is interchangable with either a canard or tail. There are several different geometries which the wing or body may have as discussed below.

1. Body

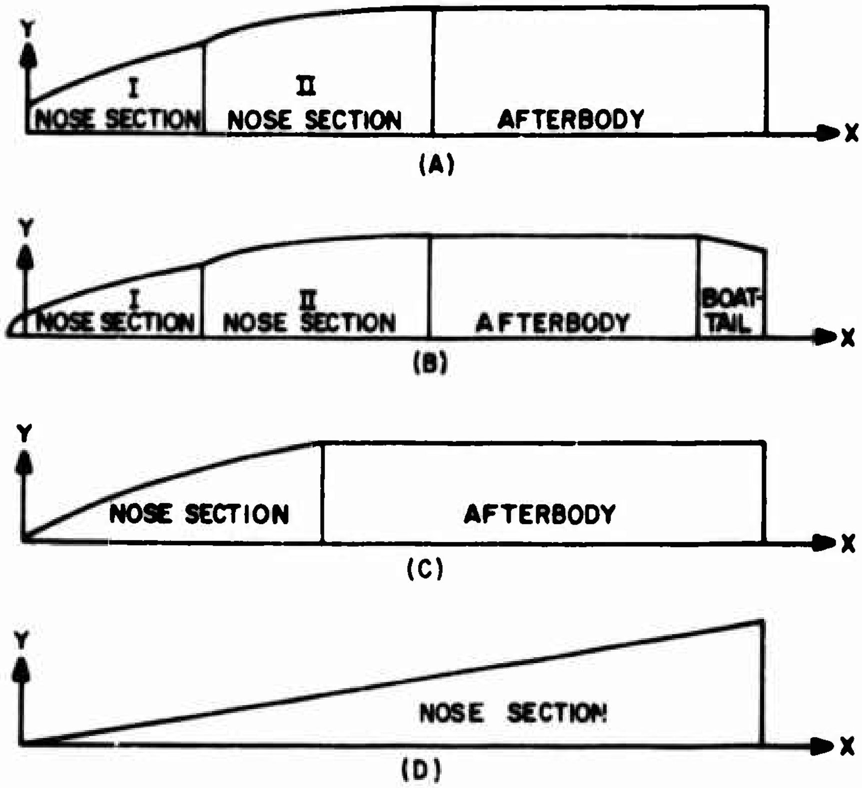
The body may have a pointed or blunted nose. Blunt noses may have spherical caps or they may be truncated as shown in Figure 3. The program automatically accounts for this, however, if the correct inputs are given as decribed in the input section. In addition to being pointed or blunt, the nose may have up to two different ogive segments present. For example, on spin-stabilized projectiles there is normally one ogive on the fuze and a different ogive between the fuze and shoulder. If the aerodynamics are desired in transonic flow, there is a minimum allowable nose length of 1.5 calibers due to the table look-up procedure used there.

The total body alone may end with the nose or it may continue with an afterbody. If an afterbody is present it is assumed to be cylindrical. Again due to the empirical estimation of aerodynamics in transonic flow, the afterbody must be less than ten calibers because this is the upper limit of the tables. Following the afterbody, a conical or ogival boattail may or may not be present. Instead of a boattail, a flare may be considered but the base drag must be disregarded because it is derived for a boattail angle. Finally, the body alone may or may not have a rotating band present.

2. Wing

The wing is assumed to have one of two airfoil sections: a biconvex or modified double wedge. Both airfoil sections may have sharp or blunt leading and trailing edges. Also, the wing thickness to chord ratio and the slope of the airfoil section may vary all along the span.

It may appear at first sight that assuming the airfoil section to be one of the two shapes above severly limits the program. This is not the case for projectiles and missiles, however, since the fin geometry normally is of a simple planform with no camber. Also, referring to Figure 4, the modified double wedge



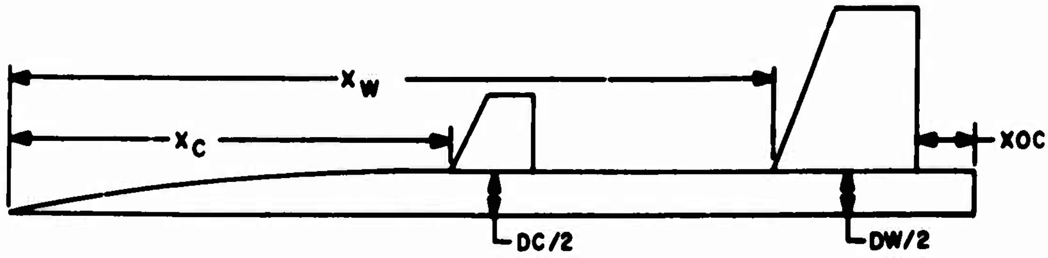
A) N SHAPE = 3; N1 ≥ 5 AND N2 ≥ 9; N BLUNT = 2, NFL = 2, NNIA = 2

B) N SHAPE = 5; N1 ≥ 5 AND N2 ≥ 9; N BLUNT = 2, NFL = 1, NNIA = 2

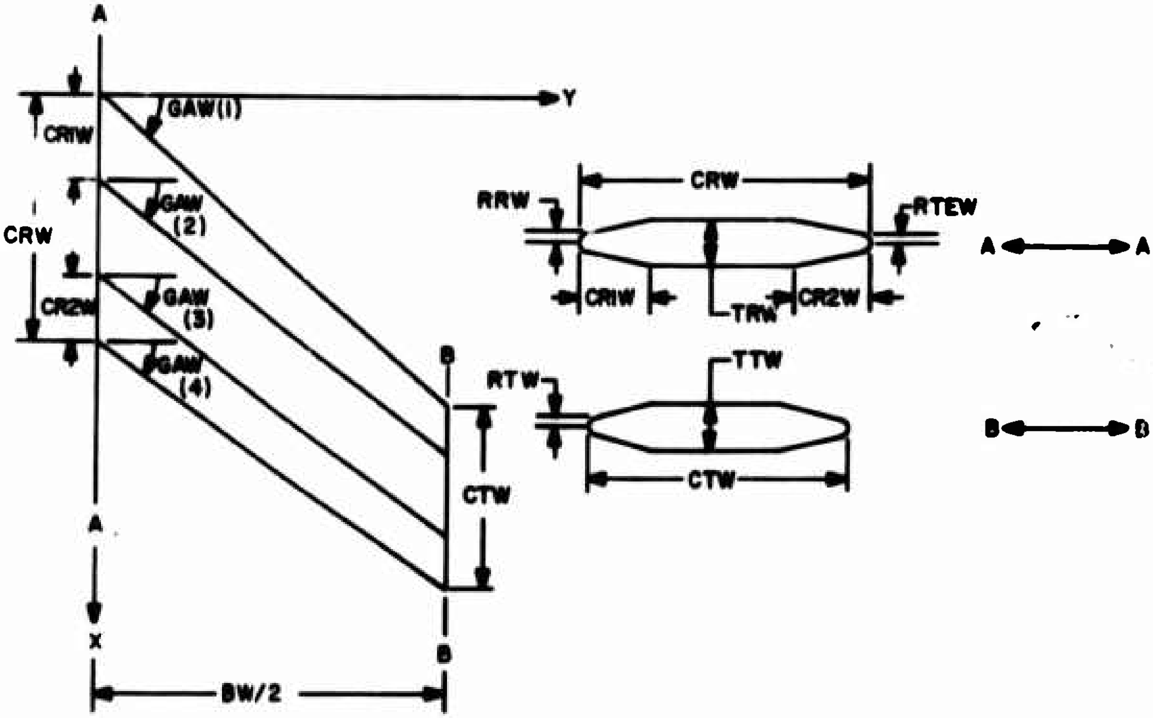
C) N SHAPE = 2; N1 = N2 ≥ 5; N BLUNT = 1

D) N SHAPE = 1; N1 = N2 ≥ 5; N BLUNT = 1

FIGURE 3. TYPICAL EXAMPLES OF INPUT OPTIONS FOR BODY CONFIGURATIONS



CANARD-BODY-TAIL CONFIGURATION



TAIL GEOMETRY

FIGURE 4. TAIL (OR CANARD) INPUT GEOMETRY NOMENCLATURE FOR A MODIFIED DOUBLE WEDGE AIRFOIL

can cover all wedge airfoil shapes by adjusting the parameters CR1W and CR2W along with the angles GAW (1) through GAW (4). For example, if a double wedge airfoil is desired then it is sufficient to make the quantity [CRW - CR1W - CR2W] equal to zero and to make GAW (2) = GAW (3).

B. Aerodynamics

As mentioned previously, the various theoretical and empirical methods used to compute the static aerodynamics are listed in Figures 1 and 2 and will not be discussed in this report as they are discussed fully in References 1 and 2. It is worthy of note that the overall guiding principle in the choice of methods listed in the above figures was to use techniques which could yield accuracies generally in the range ±10% and which were inexpensive on the computer. It is believed that this goal was accomplished in that drag and normal force for most configurations can be obtained within the above accuracies and for a cost not exceeding $75.00 for ten Mach numbers or angles of attack. The center of pressure is within a half caliber of experimental data for most configurations.

C. Subroutines

A brief description of each subroutine will aid the user in understanding the methodology and logic of the program. These descriptions follow.

1. MAIN

This subroutine acts as a control for the entire program. It handles the calling of the various subroutines that calculate the different lift and drag components. The calling of the various subroutines depend on the different options present in the program. These options are given in the input section of this report. The MAIN also handles the summation of the different components to obtain the total lift, drag, and pitching moment coefficients.

2. AINTER

A double interpolation routine used in the transonic Mach number range.

3-8. ARCOSH, ARCOS, ARSECH, ARSIN, ARSINH, ARTANH

These subroutines calculate the hyperbolic arccosine, arccosine, hyperbolic arcsecant, arcsine, hyperbolic arcsine, and the hyperbolic arctangent,

respectively. They are included because not all computers contain these particular functions in their library.

9. BASEP

Calculates the base drag for a body of revolution with or without a boattail throughout the Mach number range. It also includes an empirical estimate for the increase in base pressure drag due to the presence of fins.

10. BASEPW

Computes the drag due to trailing edge separation of a blunt trailing edge fin.

11. BLUNT

Derives the coordinates of a blunt nose tip on a body of revolution.

12. CP3DW

Determines the perturbation velocity at each point on a fin. These perturbation velocities are used by subroutine **WING** to compute pressures and forces on a fin.

13-16. DISC1, DISC2, DISC3, DISC4

These subroutines put in appropriate perturbation solutions to simulate discontinuities in body shape and curvature.

17. DIST

Computes the spanwise distribution of lifting pressure in subsonic flow.

18-19. ELIPT1, ELIPT2

These subroutines are used to evaluate the complete elliptic integrals of the first and second kind.

20. FBINT

Calculates the fin body and body fin interference. The method used is that of Nielsen and Kaattari.[3]

21. FOINT

This is a simple linear interpolation routine. It is used in subroutines TRNCNA and SUBTRN.

22-23. FD5, FDP5

Theses subroutines are used to find the derivatives of a function at a given point. The five point Lagrange method is used.

24. GCALC

Computes the spanwise interpolation function for use in subsonic lifting surface theory.

25. GEOM

This subroutine reads input body coordinates and then computes the coordinates where the flow-field properties will be calculated.

26. GEOM1

Calculates the geometric properties of wings in subsonic flow.

27. GUIDED

This subroutine is the controlling subroutine for subsonic wing lift. It establishes boundary conditions and applies the Prandtl Glauert transformation.

28. HCALC

Computes the chordwise interpolation function used in subsonic lifting surface theory.

29. HINT

Computes the chordwise integrals to be used in the chordwise interpolation functions in subroutine HCALC.

30. HYBRID

Determines the body pressure using the hybrid perturbation theory of Van Dyke. For a discussion of this theory, see Reference (2).

31-32. INTERP, INTER5

These subroutines are used to interpolate for the value of a function at a given point. Five point Lagrange interpolation is used.

33. LIFT

Acts as an executive program responsible for the calculation of fin lift. It calls the interference subroutines and combines the lift of the isolated fins with the proper interference terms to obtain all fin lift components.

34. MINVR

Solves the matrix equation $AX = B$ where A is a square coefficient matrix and B is a matrix of constant vectors. A^{-1} and $|A|$ are also available. Solution is by the Gauss-Jordan elimination method.

35. NEWRAP

Uses the Newton-Raphson method to solve for the mean skin-friction coefficient for a given Reynolds number and Mach number.

36. NEWT

Computes the pressure and static aerodynamics on the blunt portion of the nose using modified Newtonian theory. It also calculates the match point to combine Newtonian theory with perturbation theory.

37. **NORMFO**

Solves for the normal force coefficients on the various components of the body in transonic flow using mostly empirical methods.

38. **PQRINT**

Integrates the upwash effect of one wing panel on another.

39. **RBAND**

Estimates the increase in drag due to the presence of a rotating band.

40-41. **REGONE, REGTWO**

These subroutines calculate the supersonic lift and center of pressure on a fin with a subsonic leading edge and a supersonic trailing edge by linear theory.

42-46. **REG1, REG2, REG3, REG4, REG5**

These subroutines calculate the supersonic lift and center of pressure on a fin with supersonic leading and trailing edges by linear theory.

47. **RK**

Finds the solution of differential equations using the fourth-order Runge-Kutta technique.

48. **SIMP**

Simpon's rule is used to integrate surface pressures to find forces and moments on a body.

49. **SIMPW**

Intergrates wing pressure due to thickness to find wave drag on a wing by using Simpson's rule.

50. SING

Applies Mangler's principle Value technique to obtain the solution to an improper intergral.

51. SKINF

Calculates the axial force coefficient due to skin friction on the body.

52. SKINFW

This subroutine computes the skin friction drag of a wing. The Reynold's number is based on the mean geometric chord.

53. SUBCNA

Calculates the subsonic normal force coefficient and center of pressure for an isolated fin. It acts as a calling program for the subroutine that actually does the calculations.

54. SUBTRN

This subroutine calculates the transonic normal force coefficient and center of pressure for an isolated fin. The method used can be found in the USAF Stability and Control DATCOM.[4] The method used in the program is a slight modification of that found in the DATCOM, but should be more accurate because the highest subsonic value of normal force derivative and lowest supersonic value are calculated by using lifting surface theory and linear theory, respectively.

55. SUBXCP

Calculates the subsonic center of pressure for an isolated fin. The subroutine uses values of sectional center of pressure as calculated in subroutine DIST.

56. SUPCNA

Computes the supersonic normal force coefficient for an isolated fin. It acts as an executive program and it sets up fin geometry, determines what region a given point on the fin is in, and numerically adds all the lift increments in order to determine the normal force. The supersonic center of pressure for an isolated fin is also calculated in this subroutine.

57. TRANS

Determines the wave drag of a boattail in transonic flow. It is also used to calculate the nose wave drag of tangent ogives in transonic flow.

58. TRAPE

Trapezoidal rule of integration used to determine the surface area and volume of the body alone.

59. TRNCNA

This subroutine is used, along with subroutine SUBTRN, to calculate the transonic normal force coefficient. It acts as an executive program as it calls the various subprograms necessary to determine a table of transonic normal forces for an isolated fin as a function of Mach number.

60. WAVE

Integrates the body alone pressures in order to compute the static aerodynamics.

61. WING

Calculates the pressures and forces on a fin due to thickness at supersonic speeds. The airfoil thickness is assumed to be symmetrical about the x-axis. The method used is conical flow theory as modified in Reference 1.

62. WTINT

Finds the decrement in normal force derivative of the tail of a configuration due to downwash from the canards. The method used is that of Nielsen and Kaattari(3) mentioned earlier.

III. INPUT

The following is a list of the required inputs to the computer program described in this report.

CARD TYPE I FORMAT (I3)

Variable Name	Column	Variable Description
M	(1-3)	Number of cases to be run

CARD TYPE II FORMAT (4F10.4,2F15.12,2I5)

Variable Name	Column	Variable Description
AL	(1-10)	Angle of attack (Degrees)
DIA	(11-20)	Reference diameter of body (Ft)
HB	(21-30)	Mean height of the rotating band above the body surface (Calibers)
AINF	(31-40)	Speed of sound (Ft/Sec)
RHOINF	(41-55)	Density (Slugs/Ft^3)
AMUINF	(56-70)	Absolute viscosity (lb-Sec/Ft^2)
IPRINT	(71-75)	Equal 1 if pressure coefficients are to be printed Equal 2 no pressure coefficients printed
NTYPE	(76-80)	Equal 1 body alone aerodynamics calculated Equal 2 body-wing aerodynamics calculated Equal 3 body-wing-canard aerodynamics calculated Equal 4 wing or canard alone aerodynamics calculated

CARD TYPE III FORMAT (6F5.3,I5)

Variable Name	Column	Variable Description
XW	(1-5)	Distance of wing leading edge from nose tip (Calibers) see Figure 4
DELTAW	(6-10)	Wing deflection angle (Degrees)
DW	(11-15)	Diameter of body at wing root chord. If the diameter varies, an average of the body diameters at the leading and trailing edge should be used (Ft).
XC	(16-20)	Distance of canard leading edge from nose tip (Calibers)

Variable Name	Column	Variable Description
DELTAC	(21-25)	Canard deflection angle (Degrees)
DC	(26-30)	Diameter of body at canard root chord. If the diameter varies, an average of the body diameters at the leading and trailing edge should be used (Ft).
XCG	(31-35)	Reference point for moments and center of pressure (measured in calibers from most forward point of nose).
MN	(36-40)	Number of Mach numbers to be computed

CARD TYPE IV FORMAT (16F5.3)

Variable Name	Column	Variable Description
AM(ARRAY)	(1-80)	Mach numbers (Limited to 16)

CARD TYPE V FORMAT (15F5.3,I5)

Variable Name	Column	Variable Description
GAW(1)	(1-5)	Tail leading edge sweep angle (Degrees)
GAW(2)	(6-10)	Angle at which first line of sinks is swept back from Y-axis of tail (Degrees), see Figure 4.
GAW(3)	(11-15)	Angle at which second line of sinks is swept back from Y-axis of tail (Degrees)
GAW(4)	(16-20)	Tail trailing edge sweep angle (Degrees)
CRW	(21-25)	Tail root chord (Ft)
CTW	(26-30)	Tail tip chord (Ft)
BW	(31-35)	Span of isolated tail panels (Ft)
CR1W	(36-40)	Distance from tail leading edge to first discontinuity measured from root of tail parallel to freestream (Ft)
CR2W	(41-45)	Distance from tail trailing edge to first discontinuity upstream from root chord parallel to freestream (Ft)
RRW	(46-50)	Leading edge radius of tail at root chord (Ft)
RTW	(51-55)	Leading edge radius of tail at tip chord (Ft)
TRW	(56-60)	Tail thickness at root (Ft)
TTW	(61-65)	Tail thickness at tip (Ft)

Variable Name	Column	Variable Description
XOC	(66-70)	Distance of wing trailing edge from base (positive upstream of base and measured in root chord lengths)
RTEW	(71-75)	Trailing edge radius of tail at root chord (Ft)
IW	(76-80)	Equal 1 double wedge or modified double wedge airfoil; Equal 2 biconvex airfoil

CARD TYPE VI FORMAT (15F5.3,I5)

Variable Name	Column	Variable Description
GAC(1)	(1-5)	Canard Leading Edge Sweep Angle (Degrees)
GAC(2)	(6-10)	Angle at which first line of sinks is swept back from Y-axis of canard (Degrees), see Figure 1.
GAC(3)	(11-15)	Angle at which second line of sinks is swept back from y-axis of canard (Degrees)
GAC(4)	(16-20)	Canard trailing edge sweep angle (Degrees)
CRC	(21-25)	Canard root chord (Ft)
CTC	(26-30)	Canard tip chord (Ft)
BC	(31-35)	Span of isolated canard panels (Ft)
CR1C	(36-40)	Distance from canard leading edge to first discontinuity measured from root of canard parallel to freestream (Ft)
CR2C	(41-45)	Distance from canard trailing edge to first discontinuity upstream from root chord parallel to freestream (Ft)
RRC	(46-50)	Leading edge radius of canard at root chord (Ft)
RTC	(51-55)	Leading edge radius of canard at tip chord (Ft)
TRC	(56-60)	Canard thickness at root (Ft)
TTC	(61-65)	Canard thickness at tip (Ft)
XOC1	(66-70)	Distance of canard trailing edge from base of projectile (positive upstream of base and measured in root chord lengths)
RTEC	(71-75)	Trailing edge radius of canard at root chord (Ft)
IC	(76-80)	Equal 1 double wedge or modified double wedge airfoil Equal 2 biconvex airfoil

CARD TYPE VII FORMAT (8I5,4F10.5)

Variable Name	Column	Variable Description
N	(1-5)	Total number of points to be read in to describe the body alone geometry (limit of 30)
NSHAPE	(6-10)	Parameter used to describe the body geometry as defined below

Pointed bodies

NSHAPE=1 Nose only
NSHAPE=2 Nose plus afterbody
NSHAPE=3 Nose with a discontinuity (there may or may not be an afterbody present)
NSHAPE=4 Nose plus afterbody plus boattail
NSHAPE=5 Nose with discontinuity plus afterbody plus boattail

If NSHAPE=3 or 5 at least five points must be read in along each of the nose sections, even if the nose section is a straight line.

Blunted Bodies

NSHAPE must be 3 or 5
NSHAPE=3 NN1A=2 Blunted nose with a discontinuity so there are two nose sections present (no boattail present)
NSHAPE=3 NN1A=1 Blunted nose with no discontinuity (no boattail present)
NSHAPE=5 NN1A=2 Blunted nose with a discontinuity so there are two nose sections present (boattail present)
NSHAPE=5 NN1A=1 Blunted nose with no discontinuity (boattail present)
If NN1A=1, then N1=1 and N2≥5
If NN1A=2, then N1≥5 and N2≥9

N1	(11-15)	Number of points used to describe the first nose section
N2	(16-20)	Number of points used to describe the second nose section plus the number of points used to describe the first nose section.

Variable Name	Column	Variable Description
N3	(21-25)	Equal 1 conical boattail Equal 2 ogival boattail (if ogival boattail is present at least five points must be used to describe the boattail section)
NBLUNT	(26-30)	Equal 1 pointed body Equal 2 blunted body
NFL	(31-35)	Equal 1, spherical cap on nose Equal 2, truncated nose
NN1A	(36-40)	Equal 1, no discontinuities present in nose Equal 2, discontinuity present in nose so nose appears to be made of two distinct sections
C2	(41-50)	Parameter used to describe mesh spacing. For blunted or spherically capped nose, C2=.05 and for pointed nose C2=.9 are nominal values
C4	(51-60)	Another parameter used to describe mesh spacing. For blunted or spherically capped nose, C4=1; for pointed nose, C4=20 are nominal values
F	(61-70)	Constant which determines limiting body slope for a given mach number (.95 recommended)
RR	(71-80)	Radius of spherical cap or truncated nose (Calibers)

CARD TYPE VIII FORMAT (2F15.10)

Variable Name	Column	Variable Description
X(I)	(1-15)	Longitudinal body coordinate measured from nose (calibers). If nose is blunt, X(1)=0 is at the end of the spherical cap or at the truncated position.
R(I)	(16-30)	Body radius at given longitudinal station (calibers)

There are as many Card Type VIII as are needed to describe the body up to 30 points.

It should also be pointed out that if:

NTYPE=1 (Body alone) Card Types V and VI are omitted,
NTYPE=2 (Wing-body) Card Type VI is left blank or contains all zeros,
NTYPE=3 (Wing-body-canard) all Card Types contain data,

NTYPE=4 (Wing only) Type VI is left blank and Card Types VII and VIII are omitted.

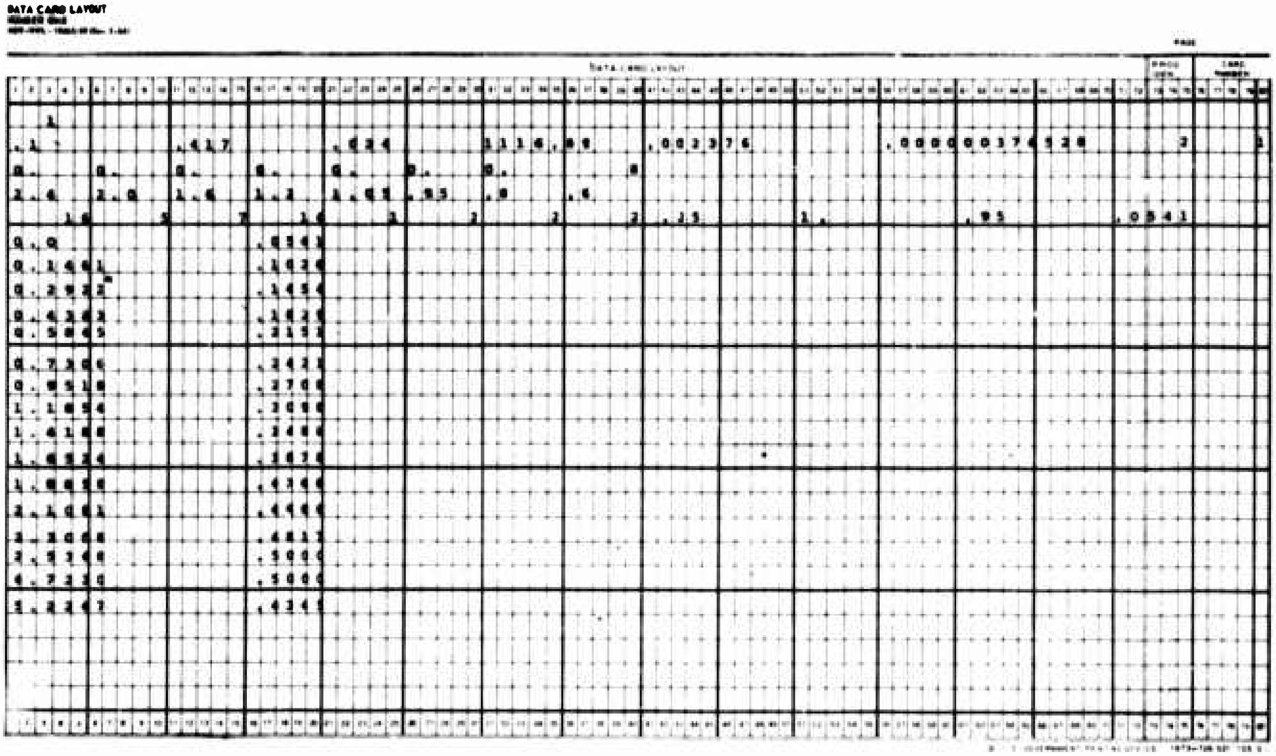
If several cases are to be computed, Card Type I is input one time only, but Card Types II - VIII are given for each case as needed.

Figure 3 shows a few typical examples of body geometry and associated parameters.

At present, the maximum Mach number that can be input is three. This is due to limitations on tables present in the program. The upper limit on Mach number may be less than this if the local body slope becomes equal to 0.95 of the Mach angle based on the freestream Mach number. Mach numbers should be read in from highest to lowest. If a Mach number is desired between 1.05 and .95, then Mach 1.05 must be included. This is because values of wave drag on boattails is assumed to vary linearly from 0 at M = .95 to an analytically calculated value at M = 1.05. Wave drag on fins is also assumed to vary linearly from 0 at M = 0.9 to an analyticallv calculated value at M = 1.05.

The shortest nose length that can be considered in the transonic flow regime is 1.5 calibers. The longest afterbody length that can be considered in the transonic flow regime is 10 calibers. These limitations are due to limits in the tables that are internal to the program.

Several sample input data sheets are shown in Figures 5 thru 8. An accompanying sketch with the geometric parameters describing each configuration is also given. Figure 5 is a body alone, Figure 6 a wing-body, Figure 7 a canard-body-tail, and Figure 8 a wing alone.



DATA CARD LAYOUT

1											
.1		.417		.024		1116.89		.002376	.0000000374528	2	1
0.	0.	0.	0.	0.	0.	0.	0				
2.4	2.0	1.6	1.2	1.05	.95	.8	.6				
16	5	7	16	1	2	2	2	2.25	1.	.95	.0541
0.0			.0541								
0.1461			.1026								
0.2922			.1454								
0.4383			.1829								
0.5845			.2153								
0.7306			.2421								
0.8516			.2700								
1.1054			.3000								
1.4166			.3466								
1.6524			.3674								
1.8858			.4346								
2.1601			.4444								
3.3008			.4813								
3.5316			.5000								
4.7210			.5000								
5.2247			.4345								

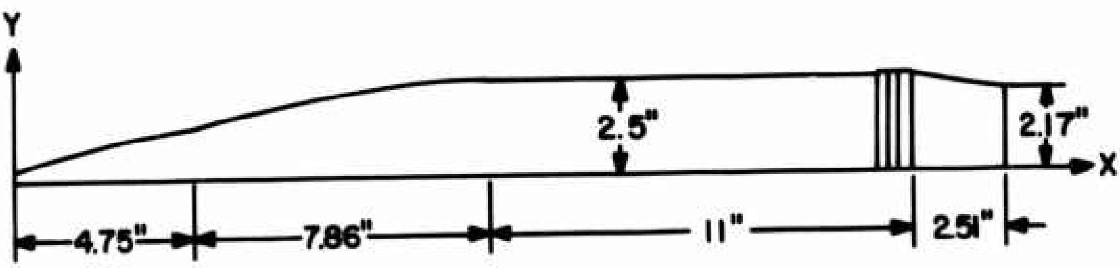
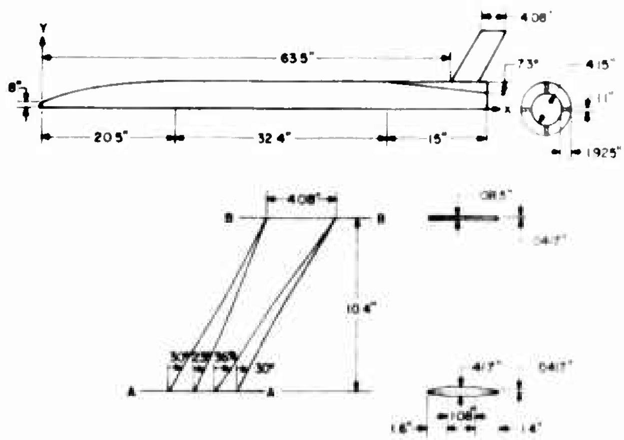


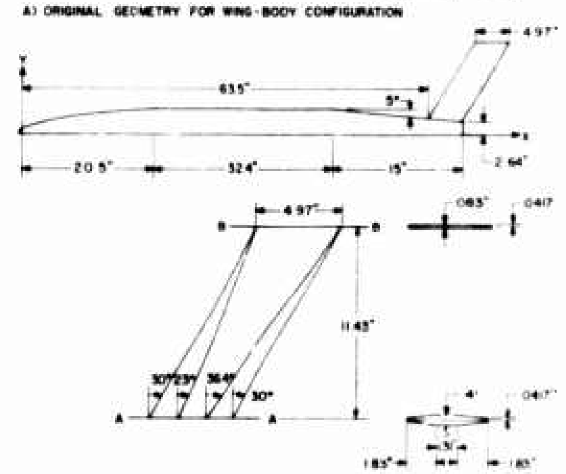
FIGURE 5 — SAMPLE INPUT DATA FOR A TYPICAL BODY ALONE CONFIGURATION

DATA CARD LAYOUT

Cols 1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80
1															
1.		.667		.025		1116.95		.0023769			.000000374528			2	2
0.02	0.	.5	0.	0.	0.	0.	8								
2.4	2.0	1.6	1.2	1.05	.95	.8	.4								
3.0	23.	36.4	30.	.4162	.4142	1.904	.153	.153	.0015	.0015	.0346	.007	.0884	.0015	1
	BLANK	CARD													
8	5	1	6	1	2	1	1	.05		1.		.95		.1	
0.			.1000												
0.5131			.2462												
1.0262			.3582												
1.5394			.4373												
2.0525			.4843												
2.5656			.5000												
6.6011			.5000												
8.5366			.3307												



A) ORIGINAL GEOMETRY FOR WING-BODY CONFIGURATION

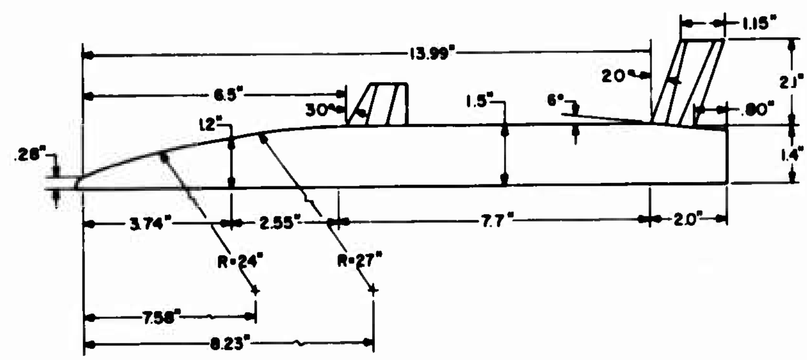


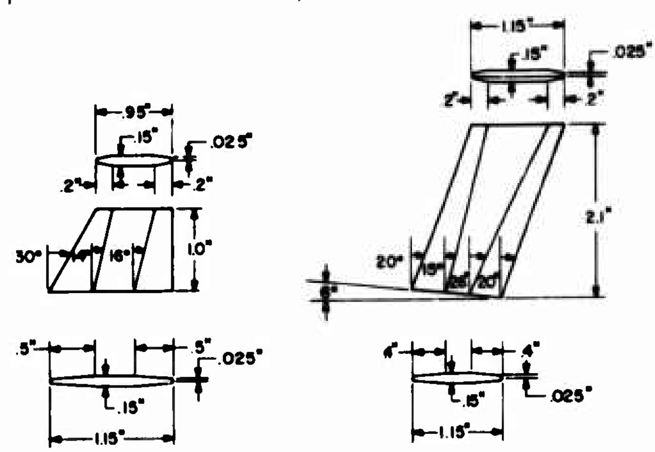
B) MODIFIED GEOMETRY FOR WING-BODY CONFIGURATION

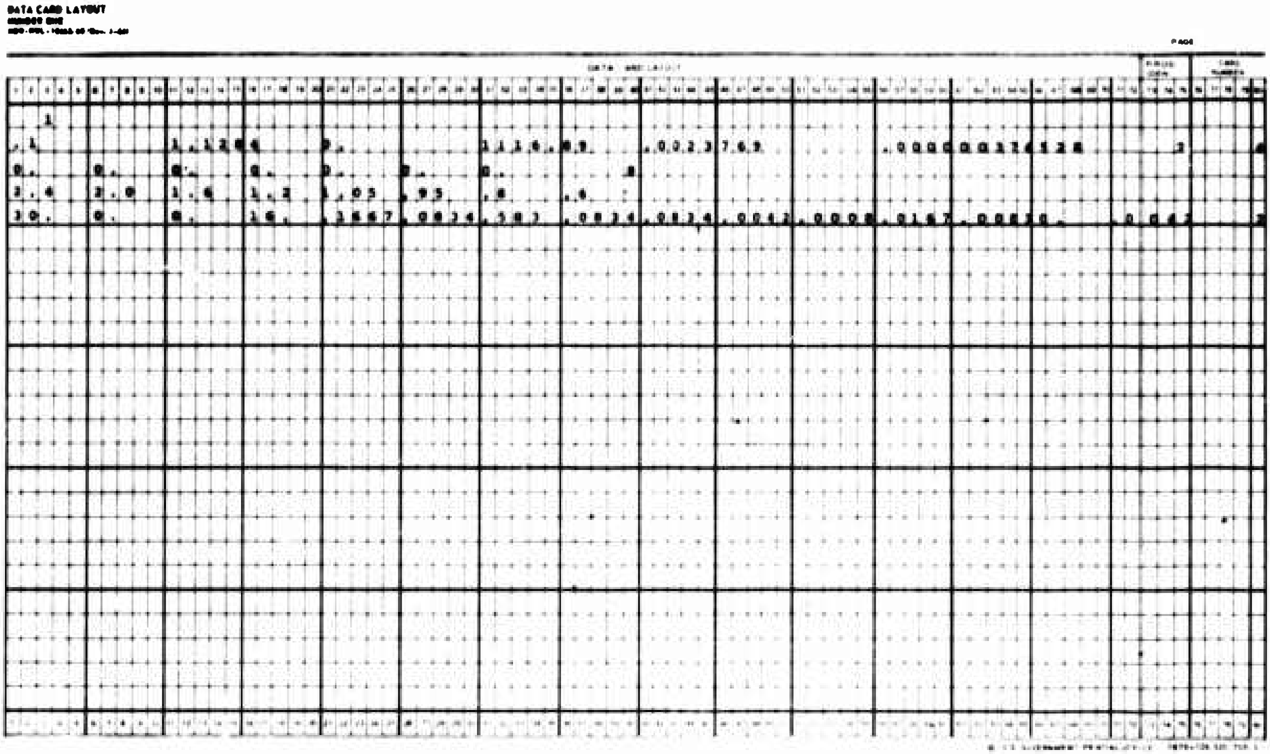
DATA CARD LAYOUT

DATA CARD LAYOUT

1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80
1															
.1		.25		0.		1116.66		.0022769			.000000374620			1	3
4.78	8.	.2417	2.26	6.	.25	6.	11								
2.8	2.4	2.0	.6	1.2	1.65	1.	.59	.9	.7	.5					
20.	15.	26.	20.	.096	.086	.25	.033	.033	.0021	.0021	.0515	.0155	.6956	.0030	[illegible]
10.	14.	16.	0.	.125	.079	.167	.042	.042	.0021	.0021	.0125	.0125	.6956	.0021	1
10	5	6	16	1	2	3	4	.05		1.	.95			.0934	
0.0			.0934												
0.2494			.1710												
0.4987			.2416												
0.7481			.3028												
0.9973			.3554												
1.2467			.3999												
1.3317			.4130												
1.416			.4266												
1.5016			.4387												
1.5867			.4498												
1.6716			.4603												
1.7567			.4698												
1.8416			.4786												
1.9267			.4865												
2.0116			.4937												
2.0967			.5000												
4.6700			.5000												
5.3600			.3945												

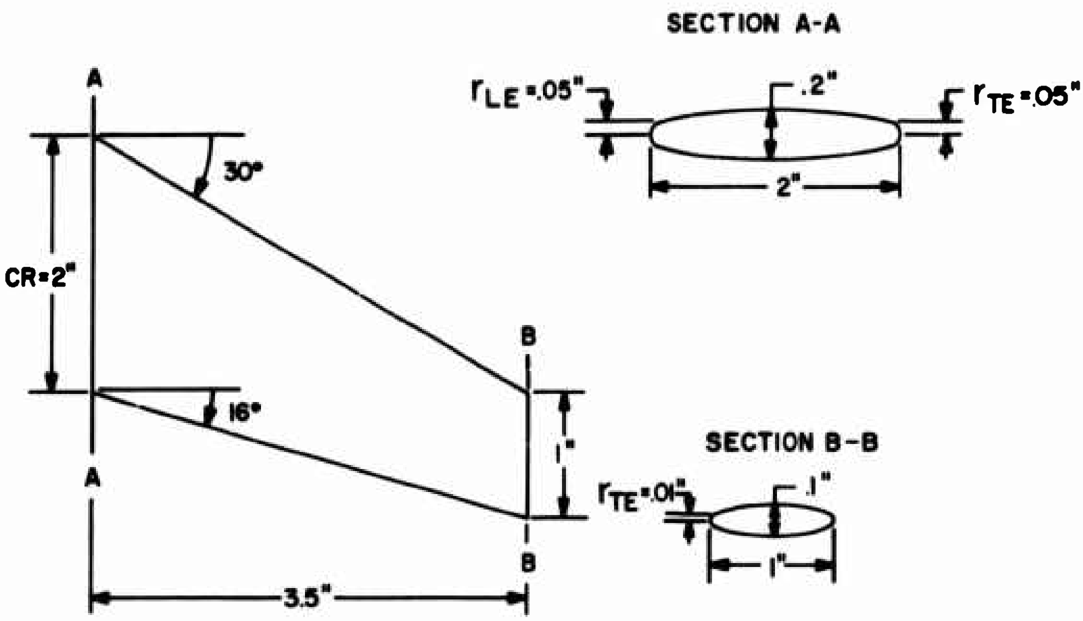






DATA CARD LAYOUT

```
  1
.1          1.1266    2.        1116.89   .0023769       .0000000174128    3     6
0.    0.    0.    0.    0.    0.    0.    .8
2.4   2.0   1.6   1.2   1.05  .95   .8    .6
30.   0.    0.    16.   .3667 .0834 .583  .0834 .0834 .0042 .0008 .0167 .00830   .0042   2
```



AR = 4.66, $(t/c)_r$ = .1 , $(t/c)_t$ = .1 , λ = .5

FIGURE 8 — SAMPLE INPUT DATA FOR A TYPICAL WING ALONE CONFIGURATION (BICONVEX AIRFOIL DESIGN)

IV. OUTPUT

Before the aerodynamic forces and moments are given, the computer printout will list the freestream conditions and the wing-body geometries that were input. The force and moment output is then given in component form. Referring to the example computer output in Figure 9 (output corresponds to geometry input of Figure 7), the first table is the body alone drag which is broken down into skin-friction, base, wave, and protrusions (rotating band). The second and third tables are the tail and canard drags (if the canard is present), also broken down into the same drag components as above. The fourth table lists the normal force contributions from all geometry components: body alone, wing alone, wing-body, body-wing, canard alone, canard-body, body-canard, and canard-tail. The last table lists the total static aerodynamics of the entire configuration. These include drag, lift, pitching moment, and center of pressure. Also included are the secant slopes of normal force and pitching moment which for small angles of attack are the normal force and pitching moment coefficient derivatives.

FIGURE 9 — SAMPLE OUTPUT FOR CANARD-BODY-TAIL CONFIGURATION OF FIGURE 7

```
                                    CASE NO.   1

ANGLE OF ATTACK =    .10DEGS            REFERENCE DIAMETER =  .250FT

                          REFERENCE  CONDITIONS

                          SPEED OF SOUND      = 1116.890 FT/SEC
                          DENSITY             =  .0023769   SLUGS/FT3
                          ABSOLUTE VISCOSITY =  .000000374528  LB-SEC/FT2


WING GEOMETRY(DOUBLE WEDGE OR MODIFIED DOUBLE WEDGE AIRFOIL DESIGN)

                      SPAN= .350FT.
                      ROOT CHORD= .096FT.
                      TIP CHORD= .096FT.
                      LEADING EDGE SWEEP=20.000EG.
                      FIRST LINE OF SINKS=15.000EGS.
                      SECOND LINE OF SINKS=26.000EGS.
                      TRAILING EDGE SWEEP=20.000EGS.
                      FIRST CHORD SEGMENT= .033FT.
                      REAR CHORD SEGMENT= .033FT.
                      ROOT THICKNESS=.0125FT.
                      TIP THICKNESS= .0125FT.
                      LEADING EDGE RADIUS AT ROOT= .0021FT.
                      LEADING EDGE RADIUS AT TIP= .0021FT
                      TRAILING EDGE BLUNTNESS= .0042FT
                      DEFLECTION ANGLE 0.000EGS.


CANARD GEOMETRY(DOUBLE WEDGE OR MODIFIED DOUBLE WEDGE AIRFOIL DESIGN)

                      SPAN= .167FT.
                      ROOT CHORD= .125FT.
                      TIP CHORD= .079FT.
                      LEADING EDGE SWEEP=30.000EG.
                      FIRST LINE OF SINKS=14.000EGS.
                      SECOND LINE OF SINKS=16.000EGS.
                      TRAILING EDGE SWEEP= 0.000EGS.
                      FIRST CHORD SEGMENT= .042FT.
                      REAR CHORD SEGMENT= .042FT.
                      ROOT THICKNESS=.0125FT.
                      TIP THICKNESS= .0125FT.
                      LEADING EDGE RADIUS AT ROOT= .0021FT.
                      LEADING EDGE RADIUS AT TIP= .0021FT
                      TRAILING EDGE BLUNTNESS= .0042FT
                      DEFLECTION ANGLE 0.000EGS.
```

BODY COORDINATES

X	R
0.0000	.0934
.2494	.1718
.4987	.2416
.7481	.3028
.9973	.3554
1.2467	.3999
1.3317	.4138
1.4167	.4266
1.5016	.4387
1.5867	.4498
1.6716	.4603
1.7567	.4698
1.8416	.4786
1.9267	.4865
2.0116	.4937
2.0967	.5000
4.6700	.5000
5.3400	.3949

FIGURE 9 (CONTINUED)

BODY AXIAL FORCE CONTRIBUTIONS

MACH NO.	SKIN FRICTION	BASE PRESSURE	PRESSURE	PROTRUSIONS	TOTAL
2.800	.0318	.0731	.1474	0.0000	.2522
2.400	.0346	.0902	.1493	0.0000	.2741
2.000	.0379	.1193	.1521	0.0000	.3093
1.600	.0413	.1555	.1608	0.0000	.3576
1.200	.0448	.1821	.1717	0.0000	.3987
1.050	.0462	.1813	.1795	0.0000	.4070
1.000	.0466	.1730	.1196	0.0000	.3392
.950	.0471	.1545	.0583	0.0000	.2599
.900	.0475	.1322	.0246	0.0000	.2043
.700	.0488	.1102	0.0000	0.0000	.1590
.500	.0495	.1019	0.0000	0.0000	.1514

WING AXIAL FORCE CONTRIBUTIONS

MACH NO.	SKIN FRICTION	BASE PRESSURE	PRESSURE	TOTAL
2.800	.0065	.0081	.0991	.1137
2.400	.0068	.0105	.1055	.1228
2.000	.0071	.0137	.1160	.1368
1.600	.0072	.0185	.1380	.1638
1.200	.0069	.0264	.2368	.2701
1.050	.0066	.0279	.2977	.3323
1.000	.0065	.0276	.2233	.2573
.950	.0063	.0248	.1489	.1799
.900	.0061	.0207	.0744	.1012
.700	.0053	.0179	0.0000	.0232
.500	.0063	.0175	0.0000	.0238

CANARD AXIAL FORCE CONTRIBUTIONS

MACH NO.	SKIN FRICTION	BASE PRESSURE	PRESSURE	TOTAL
2.800	.0033	.0039	.0388	.0460
2.400	.0035	.0050	.0413	.0498
2.000	.0036	.0065	.0454	.0555
1.600	.0037	.0088	.0537	.0662
1.200	.0036	.0126	.0722	.0883
1.050	.0035	.0133	.1000	.1168
1.000	.0034	.0131	.0750	.0915
.950	.0033	.0118	.0500	.0651
.900	.0032	.0093	.0250	.0381
.700	.0027	.0085	0.0000	.0112
.500	.0031	.0084	0.0000	.0114

NORMAL FORCE CONTRIBUTIONS

MACH NO.	BODY ALONE	WING ALONE	CANARD ALONE	WING-BODY	BODY-WING	CANARD-BODY	BODY-CANARD	CANARD-WING	TOTAL
2.8000	.0057	.0017	.0008	.0021	.0000	.0013	.0002	-.0002	.0091
2.4000	.0054	.0021	.0010	.0025	.0001	.0015	.0002	-.0003	.0094
2.0000	.0048	.0026	.0012	.0031	.0001	.0018	.0003	-.0005	.0097
1.6000	.0040	.0035	.0015	.0042	.0002	.0023	.0004	-.0008	.0104
1.2000	.0031	.0056	.0020	.0069	.0005	.0031	.0008	-.0017	.0127
1.0500	.0031	.0044	.0013	.0053	.0015	.0020	.0013	-.0009	.0123
1.0000	.0031	.0039	.0014	.0048	.0015	.0022	.0014	-.0008	.0121
.9500	.0031	.0027	.0013	.0032	.0010	.0021	.0013	-.0005	.0101
.9000	.0031	.0021	.0014	.0026	.0008	.0021	.0013	-.0004	.0094
.7000	.0027	.0046	.0014	.0056	.0017	.0022	.0014	-.0010	.0127
.5000	.0026	.0042	.0013	.0051	.0016	.0021	.0013	-.0009	.0119

TOTAL STATIC AERODYNAMICS(FORCE/ALPHA)

MACH NO.	CD	CN	CL	CM	CNAL	CMAL	XCP/D
2.800	.4119	.0091	.0084	-.024	5.233	-13.645	2.6074
2.400	.4467	.0094	.0086	-.024	5.368	-14.023	2.6124
2.000	.5016	.0097	.0088	-.026	5.547	-14.684	2.6471
1.600	.5879	.0104	.0093	-.029	5.937	-16.517	2.7822
1.200	.7571	.0127	.0114	-.040	7.298	-22.836	3.1327
1.050	.8560	.0123	.0108	-.038	7.037	-21.506	3.0560
1.000	.6881	.0121	.0109	-.035	6.932	-20.231	2.9185
.950	.5050	.0101	.0093	-.026	5.809	-14.718	2.5337
.900	.3436	.0094	.0088	-.022	5.410	-17.626	2.3337
.700	.1935	.0127	.0123	-.041	7.253	-23.379	3.2231
.500	.1067	.0119	.0116	-.038	6.823	-21.853	3.2028

V. COMPARISON WITH EXPERIMENT

Three cases are considered to show, first of all, the general accuracy of the method when compared with experiment and, second, how the program can be used to obtain engineering estimates of aerodynamics for configurations which do not exactly fit into one of the four categories listed previously. The three configurations are a body alone, a wing-body in which the wing is mounted on a strake, and a canard-body-tail in which the tail does not have streamwise tips.

The first of these configurations is the 5"/54 Rocket Assisted Projectile (body alone) for which the configuration geometry and input data are given in Figure 5 and the aerodynamics in Figure 10. This particular spin stabilized projectile has a nose length of about 2.5 calibers and a boattail length of 0.5 caliber. The theoretical drag coefficient is in very good agreement with experiment throughout the Mach number range. Fair agreement is obtained for normal force coefficient derivative and center of pressure. The normal force coefficient derivative is generally low in the lower supersonic speed range and approaches the experimental data at moderate supersonic Mach numbers.

A wing-body configuration is shown in Figure 6 and the corresponding aerodynamics in 11A and 11B. Note that in Figure 6. the tails are mounted on strakes which raises the question, "What does one use for the base diameter and wing planform?" The base diameter mainly determines the afterbody drag and the wing planform the wing lift. Since both of these quantities are a direct function of the base area and wing area respectively, it seems reasonable to compute these areas and then define the base diameter and wing planform from them. Thus the base area is computed including the strakes and then an equivalent base diameter defined. Next, the total wing area including the strake planform area, is computed and an equivalent wing obtained by adding this additional area to the chord and span. Although this does not change the configuration lift appreciably when based on wing area, it does change the lift considerably here because the wing lift is based on the body cross-sectional area. Using the above geometry modifications, the aerodynamics were computed and compared with experimental data in Figures 11A and 11B. The drag and center of pressure are shown in 11A and the normal force coefficient derivative in 11B. Excellent agreement with experiment is obtained for normal force and center of pressure. The theoretical drag is about ten percent high at transonic Mach numbers but according to Reference 5, the blockage of the test model in the wind tunnel was too high. Normally when the wind tunnel model is too large (too much blockage), drag values measured in the transonic Mach range fall off and it appears that this may have happened in this case to account for some of the above discrepency.

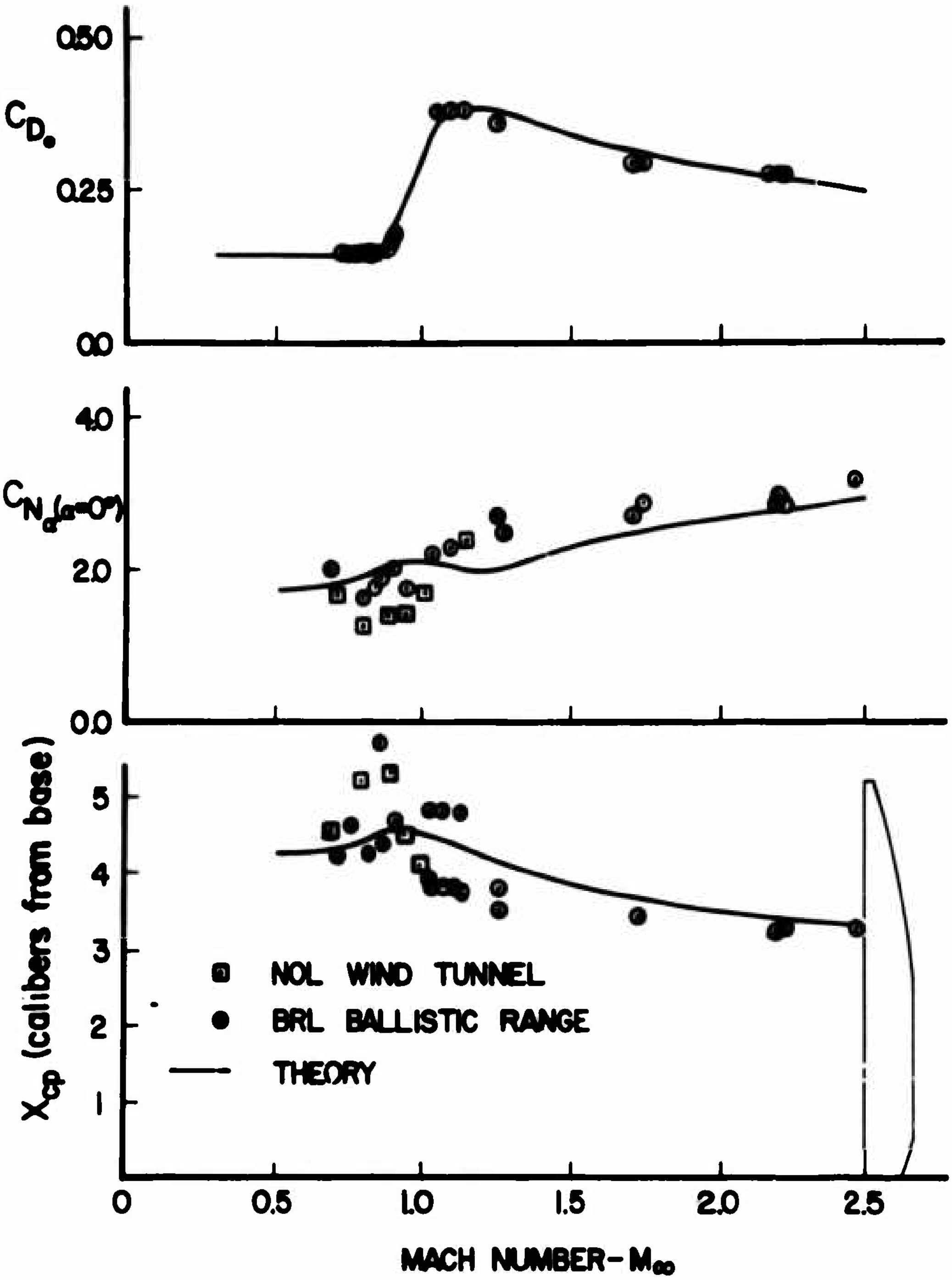


FIGURE 10

Comparison Theory and Test Data for 5"/54 Rap Projectile

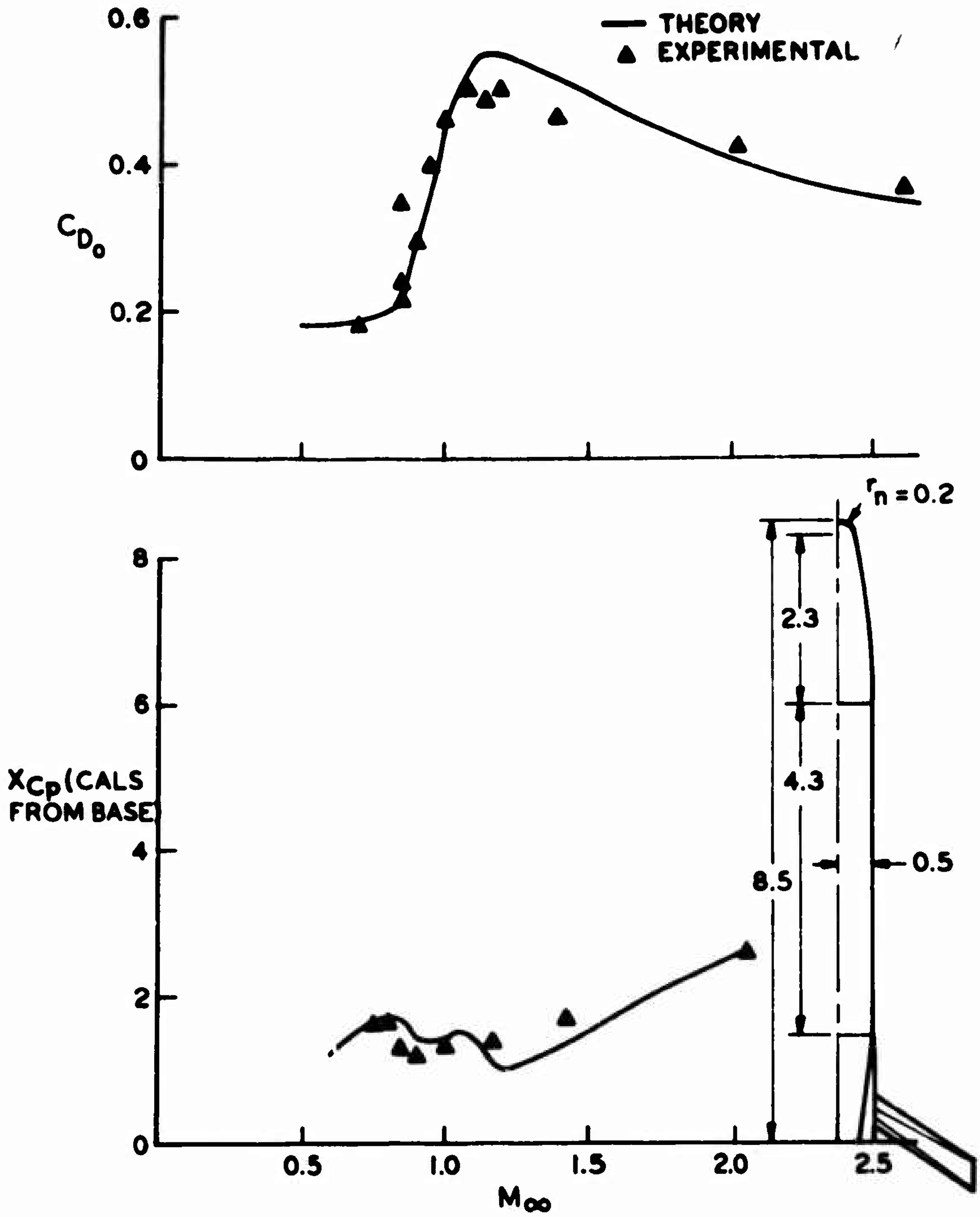


FIGURE 11(A)

Drag and Center of Pressure for a Typical Missile Configuration; $AR = 4.5$

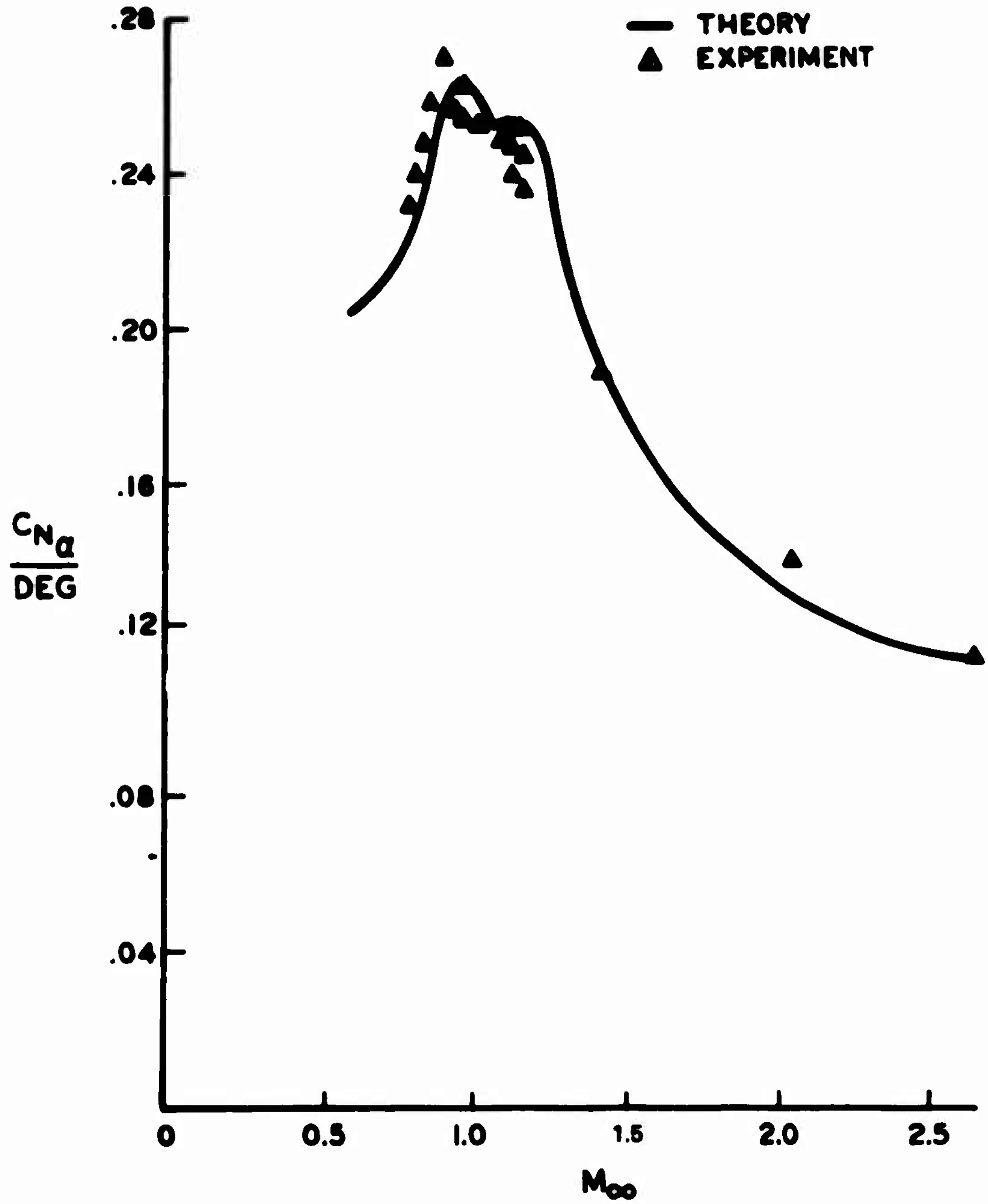


FIGURE 11(B)

Normal Force Coefficient Derivative for a Typical Missile Configuration; Æ=4.5

The third geometry considered is a very general canard-body-tail shown schematically in Figure 12A along with the normal force and center of pressure. Note that the tail does not have streamwise tips so the total wing area is again computed and an equivalent span calculated based on the chord and wing area. This gives reasonable values for normal force and center of pressure (Figure 12A), although it appears the tail alone lift is about ten percent too high causing a rearward shift in the center of pressure. The drag of the body alone, along with the canard and tail components, is shown in Figure 12B. The body alone drag agrees well with experiment in subsonic and supersonic flow but is unacceptable in transonic flow. This is because of the sixty percent blunt nose which the empirical transonic drag methodology does not account for. The wing drag is also high in transonic flow, but this is caused by the increase in body base pressure due to the presence of tail surfaces. This increase in drag is included in the curves at the bottom of Figure 12B. The empirical estimates of the body base pressure change due to fins is much higher for this case than the data suggest. However, the total configuration drag agrees with experiment within the accuracy bounds previously set forth, except in transonic flow.

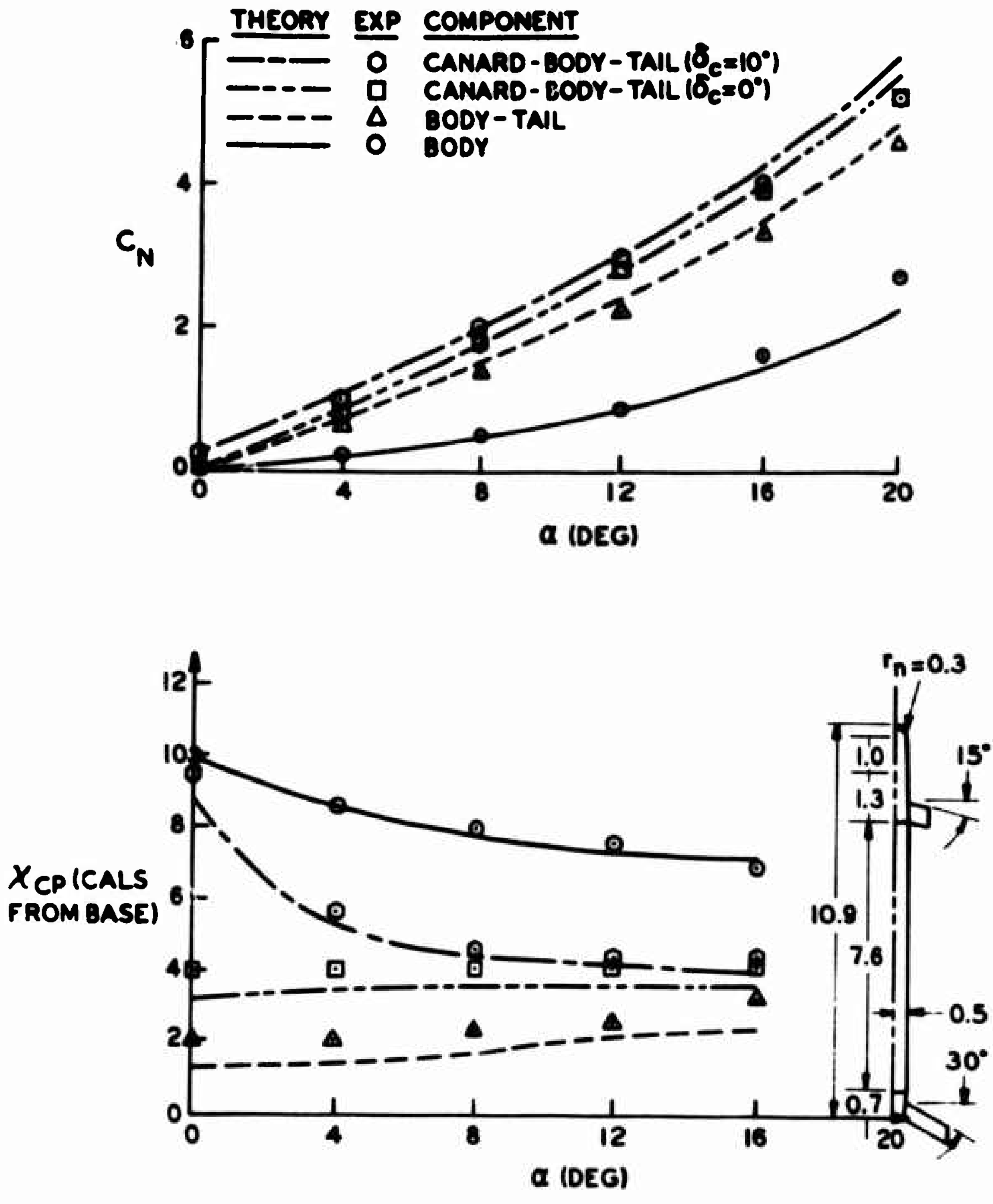


FIGURE 12(A)

Normal Force and Center of Pressure of
A Missile Configuration; AR_t =4, AR_c =2, M_∞ =1.6

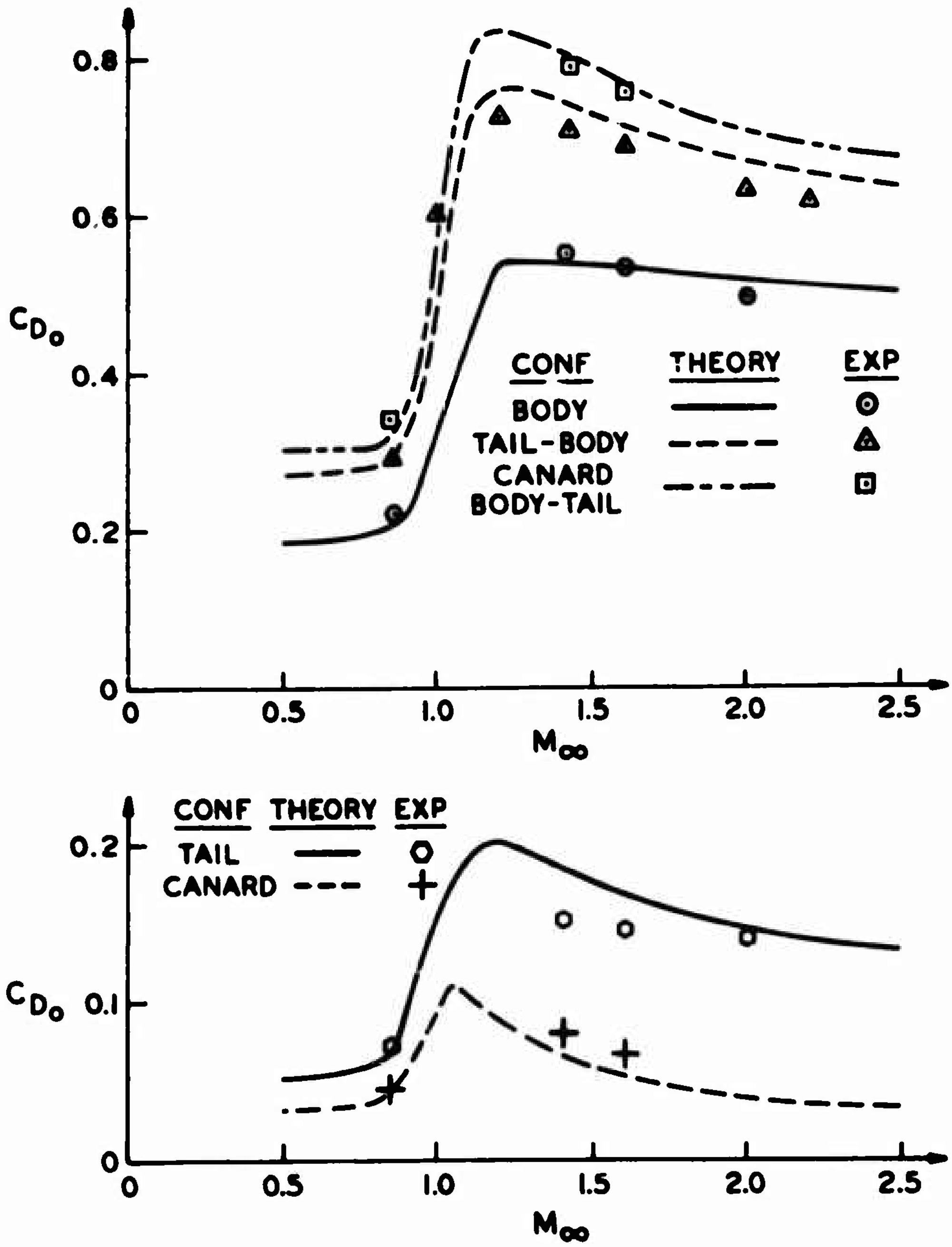


FIGURE 12(B)

Drag of a Missile Configuration and Its Components

REFERENCES

1. Moore, F. G., ***Aerodynamics of Guided and Unguided Weapons: Part I – Theory and Application***, NWL Technical Report TR-3018, December 1973.

2. Moore, F. G., ***Body Alone Aerodynamics of Guided and Unguided Projectiles at Subsonic, Transonic, and Suppersonic Mach Numbers***, NWL Technical Report TR-2796, November 1972.

3. Nielsen, J. N. and W. C. Pitts, ***Wing-Body Interference at Supersonic Speeds With an Application to Combinations With Retangular Wings***, NACA Technical Note TN-2677, 1952.

4. Douglass Aircraft Co., Inc., **USAF Stability and Control DATCOM**, Revisions by Wright Patterson Air Force Base, July 1963, 2 Vols.

5. Touch, L. M., ***Transonic Wall Interference Effects on Bodies of Revolution***, AIAA Paper No. 72-1008.

APPENDIX A
Glossary

Glossary

$\mathcal{R}_c$	Aspect ratio of canard
$\mathcal{R}_t$	Aspect ratio of tail
C_{D_0}	zero lift drag coefficient
C_L	Lift coefficient
C_M	Pitching moment coefficient
C_{M_α}	Pitching moment coefficient derivative
C_N	Normal force coefficient
C_{N_α}	Normal force coefficient derivative
M_∞	Freestream Mach number
r_{LE}	Leading edge radius of tail or canard (ft)
r_{TE}	Trailing edge radius of wing (ft)
$(t/c)_r$	Thickness to chord ratio of wing at root
$(t/c)_t$	Thickness to chord ratio of wing at tip
x,y	Coordinates with x along body and y out right wing
x_{cp}	Center of pressure measured in calibers from nose tip unless otherwise specified
α	Angle of attack
δ_c	Canard deflection angle
λ	Wing taper ratio

APPENDIX B
Computer Program Listing

```
      PROGRAM MAIN(OUTPUT,INPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON/GEOM/RP(6),X(30),R(30),C2,N,NSHAPE,N1,N2,XB(225),RB(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NBLUNT,NN,NNI,IPPINT,NN1A
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,NNIA
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,CABLW
      COMMON/GEO4/K,F,PR,RREF
      COMMON/DAT1/ T(100),AK(100),AE(100),C(225),C1(225),C3
      COMMON/DISC/ I,JK,AI2,SUM,JH,PI
      COMMON/BASE/CAB,CNB,CMB,TOC,XOC,NTYPE
      COMMON/BAND/CAP,CNP,CMP,HB
      COMMON/DIS1/ J1,J3
      COMMON/WAVE/CABL,CNBL,CMBL,CAW,CNW,CMW
      COMMON/VOL/ VOL,CAF,CNF,CMF,RN,DIA,XP,AP,VOLN,CR,CT,BW,CAFWI
      COMMON/ICOU/ ICOUNT
      COMMON/F/CNRF,CNTB,CNBT,CMRF,CMBT,CMTB
      COMMON/G/ CNC,CNFB,CNBF,CMFB,CMBF,CMC,CNTV,CMTV
      DIMENSION AM(20),CN(20),CM(20),CL(20),CD(20),XCP(20),CNAL(20),
     1CMAL(20),CA1(20),CAF1(20),CAB1(20),CAW1(20),CAP1(20),ETA(9),
     2ALOD(9),AMC(10),CDC(10)
      DIMENSION GAW(4),GAC(4),CAWW(20),CAFW(20),CAFC(20),CAWC(20)
      DIMENSION CABC1(20),CABW1(20),CMWI(20),CMCA(20),CMWB(20),CMBW(20)
     1,CMCB(20),CMBC(20),CMCW(20)
      DIMENSION CA2(20),CA3(20),CNWI(20),CNCA(20),CNWB(20),CNBW(20),
     1CNCB(20),CNBC(20),CNCW(20),CNT(20),CAT(20),CMT(20)
      DIMENSION CDCW1(10),CDCW0(10),ASRA(10),CNVIS(20),CMVIS(20)
      DATA(ETA(I),I=1,7)/.53,.57,.613,.64,.665,.70,.765/
      DATA(ALOD(I),I=1,7)/1.,2.,4.,6.,8.,12.,20./
      DATA(AMC(I),I=1,9)/0.,.3,.4,.5,.7,.8,.9,1.,1.4/
      DATA(CDC(I),I=1,9)/1.2,1.2,1.25,1.35,1.74,1.82,1.82,1.8,1.53/
      DATA(CDCW1(I),I=1,10)/6.,4.55,3.5,2.9,2.4,2.12,2.0,1.97,1.97,1.97/
      DATA(ASRA(I),I=1,10)/0.,0.5,1.,1.5,2.,2.5,3.,4.,7.,15./
      DATA(CDCW0(I),I=1,10)/2.,1.6,1.3,1.18,1.02,0.9,0.8,0.78,.76,.76/
C     M=NUMBER OF CASES TO BE COMPUTED.
C     AL=ANGLE OF ATTACK(DEG) DIA=REFERENCE DIAMETER OFF BODY(FT).
C     AINF,RHOINF,AMUINF ARE THE FREESTREAM REFERENCE CONDITIONS FOR
C     SPEED OF SOUND(FT/SEC), DENSITY(SLUGS/FT**3),AND ABSOLUTE
C     VISCOSITY(LB-SEC/FT**2) RESPECTIVELY AT THE GIVEN ALTITUDE
C     IPRINT=1 IF PRESSURE COEFFICIENTS ARE TO BE PRINTED =2 OTHERWISE
C HB=MEAN HEIGHT OF ROTATING BAND IN CALIBERS. IF NO BAND PRESENT HB=0.
C     NTYPE=1 FOR BODY ALONE?=2 FOR WING PLUS BODY?=3 FOR WING PLUS BODY PLUS
C     CANARDS?=4 FOR WING OR CANARDS ALONE.
C     MN=NUMBER OF MACH NUMBERS TO COMPUTE THE FORCE COEFFICIENTS OF
C     A PARTICULAR CASE.
C    GAW(I)=ANGLES(IN DEGS.) WHICH THE SOURCES ARE SWEPT BACK OF Y-AXIS FOR WING
C    CRW = WING ROOT CHORD MEASURED PARALLEL TO FREESTREAM(FT).
C    CTW = WING TIP  CHORD MEASURED PARALLEL TO FREESTREAM(FT).
C    BW  = WING SPAN MEASURED PERPENDICULAR TO BODY AXIS OF SYMMETRY(FT).
C    CR1W= DISTANCE FROM WING LEADING EDGE TO FIRST DISCONTINUITY MEASURED FROM
C      ROOT OF WING AND PARALLEL TO FREESTREAM(FT).
C    CR2W= DISTANCE FROM WING TRAILING EDGE TO FIRST DISCONTINUITY UPSTREAM
C   FROM ROOT CHORD AND PARALLEL TO FREESTREAM(FT).
C     RRW=LEADING EDGE RADIUS OF WING AT ROOT CHORD.
C     RTW=LEADING EDGE RADIUS OF WING AT TIP CHORD.
C     RTEW=TRAILING EDGE RADIUS OF WING AT ROOT CHORD
```

```
C      IT IS ASSUMED THE TRAILING EDGE RADIUS AT THE TIP CHORD IS RTL*RTW/RRW
C     TRW = WING THICKNESS AT ROOT(FT)
C     TTW = WING THICKNESS AT TIP(FT)
C     MW  = NUMBER OF PLANES ALONG THE SEMISPAN OF WING WHERE PRESSURES ARE TO
C            BE CALCULATED.
C      IW=1 FOR DOUBLE WEDGE OR MODIFIED DOUBLE WEDGE, IW=2 FOR
C          BICONVEX AIRFOIL SECTION
C     GAC(I),CRC,CTC,BC,CR1C,CR2C,RRC ,RTC ,TRC,TTC,MC    SAME AS THE ABOVE
C         DEFINITIONS EXCEPT FOR CANARDS.
C      XOC=DISTANCE(IN CHORD LENGTHS) OF WING TRAILING EDGE FROM
C          BASE(POSITIVE UPSTREAM OF BASE).
C      XC,XW= DISTANCE(IN CALIBERS) OF CANARD AND WING LEADING EDGE FROM NOSE TIP
C      DELTAW,DELTAC=TAIL AND CANARD DEFLECTION ANGLES(IN DEGREES)
C      DW,DC=DIAMETER OF BODY(IN FEET) AT TAIL AND CANARD ROOT CHORD. IF THE
C      DIAMETER VARIES, AN AVERAGE OF THE BODY DIAMETERS AT THE LEADING AND
C      TRAILING EDGES SHOULD BE USED.
C      XCG=REFERENCE POINT FOR MOMENTS AND CENTER OF PRESSURE(MEASURED IN
C      CALIBERS FROM MOST FORWARD POINT OF NOSE). CENTER OF PRESSURE IS MEASURED
C      POSITIVE AFT OF THE REFERENCE POINT AND PITCHING MOMENT POSITIVE NOSE UP.
       READ(5,50) M
   50  FORMAT(I3)
       DO 27 MM=1,M
       K11=0
       READ(5,43) AL,DIA,HB,AINF,RHOINF,AMUINF,IPRINT,NTYPE
   43  FORMAT(4F10.4,2F15.12,2I5)
       AREF1=3.14159*DIA**2/4.
       WRITE(6,6)  MM,AL,DIA
    6  FORMAT(/////,60X,*CASE NO.*,I3,//,30X,*ANGLE OF ATTACK =*,F6.2,
      1*DEGS*,10X,*REFERENCE DIAMETER =*,F6.3,*FT*,//)
       READ(5,163) XW,DELTAW,DW,XC,DELTAC,DC,XCG,MN
  163  FORMAT(7F5.3, I5)
       WRITE(6,7) AINF,RHOINF,AMUINF,XCG
    7  FORMAT(54X,*REFERENCE  CONDITIONS*,//,54X,*SPEED OF SOUND      =*,
      1F9.3,* FT/SEC*,/,54X,*DENSITY             =*,F10.7,*  SLUGS/FT**3
      2   *,/,54X,*ABSOLUTE VISCOSITY =*,F15.12,*  LB-SEC/FT**2*,/,54X,
      3*MOMENT REFERENCE =*,F6.2,*CALIBERS FROM NOSE TIP*,//)
       AL=AL/57.29583
       ICOUNT=0
       READ(5,15) (AM(I),I=1,MN)
   15  FORMAT(16F5.3)
       KOH=0
       DO 1 J=1,MN
       CN(J)=0.
       CM(J)=0.
       CAF=0.
       CAB=0.
       CAW=0.
       CAP=C.
       CNV=0.
       CMV=C.
       CNF=C.
       CNB=C.
       CNW=C.
       CNP=C.
       CMF=C.
```

```
      CMB=0.
      CMW=0.
      CMP=0.
      CMV=0.
      CAFW(J)=0.
      CABW1(J)=0.
      CAWW(J)=0.
      CA2(J)=0.
      CAFC(J)=0.
      CABC1(J)=0.
      CAWC(J)=0.
      CA3(J)=0.
      CNWI(J)=0.
      CNCA(J)=0.
      CNWB(J)=0.
      CNBW(J)=0.
      CNCB(J)=0.
      CNBC(J)=0.
      CNCW(J)=0.
      CNT(J)=0.
      CNAL(J)=0.
      CMAL(J)=0.
      XCP(J)=0.
      CMT(J)=0.
      CMWI(J)=0.
      CMCA(J)=0.
      CMWB(J)=0.
      CMBW(J)=0.
      CMCB(J)=0.
      CMBC(J)=0.
      CMCW(J)=0.
      CNVIS(J)=0.
      CMVIS(J)=0.
      CNRF=0.
      CNTB=0.
      CNBT=0.
      CMRF=0.
      CMBT=0.
      CMTB=0.
      CMC=0.
      CNFB=0.
      CNBF=0.
      CNC=0.
      CMFB=0.
      CMBF=0.
      CNTV=0.
      CMTV=0.
      ICOUNT=ICOUNT+1
      VOVS=AM(J)
      PREF=0.5
      BETA=SQRT(ABS(VOVS**2-1.))
      IF(BETA.LE.0.319) BETA=0.319
      VINF=VOVS*AINF
      RN=RHOINF*VINF/AMUINF
      IF(NTYPE.EQ.1) GO TO 62
```

```
      IF(ICOUNT.GT.1) GO TO 59
   53 READ(5,57) GAW(1),GAW(2),GAW(3),GAW(4),CRW,CTW,BW,CR1W,CR2W,RRW,
     1RTW,TRW,TTW,XOC,RTEW,IW
      IF(GAW(1).LE.1.)GAW(1)=1.
   57 FORMAT(15F5.3,I5)
      MW=1
      TOC=TRW/CRW
      IF(IW.EQ.2) GO TO 64
      WRITE(6,63)
      DTEW=2.*RTEW
      WRITE(6,71) BW,CRW,CTW,GAW(1),GAW(2),GAW(3),GAW(4),CR1W,CR2W,
     1TRW,TTW,RRW,RTW,DTEW,DELTAW
   71 FORMAT(50X,*SPAN=*,F5.3,*FT.*,/,50X,*ROOT CHORD=*,F5.3,*FT.*,/,50
     1X,*TIP CHORD=*,F5.3,*FT.*,/,50X,*LEADING EDGE SWEEP=*,F5.2,*DEG.*,
     2/,50X,*FIRST LINE OF SINKS=*,F5.2,*DEGS.*,/,50X,*SECOND LINE OF SI
     3NKS=*,  F5.2,*DEGS.*,/,50X,*TRAILING EDGE SWEEP=*,F5.2,*DEGS.*,/
     4,50X,*FIRST CHORD SEGMENT=*,F5.3,*FT.*,/,50X,*REAR CHORD SEGMENT=*
     5,F5.3,*FT.*,
     6/,50X,*ROOT THICKNESS=*,F5.4,*FT.*,/,50X,*TIP THICKNESS=*,F6.4,
     7*FT.*,/,50X,*LEADING EDGE RADIUS AT ROOT=*,F6.4,*FT.*,/,50X,
     8*LEADING EDGE RADIUS AT TIP=*,F6.4,*FT*,/,50X,*TRAILING EDGE BLUNT
     9NESS=*,F6.4,*FT*,/,50X,*DEFLECTION ANGLE*,F5.2,*DEGS.*,///)
   63 FORMAT(//,20X,*WING GEOMETRY(DOUBLE WEDGE OR MODIFIED DOUBLE WEDGE
     1 AIRFOIL DESIGN)*,//)
      GO TO 140
   64 WRITE(6,65)
   65 FORMAT(//,40X,*WING GEOMETRY(BICONVEX AIRFOIL DESIGN)*,//)
      WRITE(6,66) BW,CRW,CTW,GAW(1),TRW,TTW,RRW,RTW,DELTAW
   66 FORMAT(50X,*SPAN=*,F5.3,*FT.*,/,50X,*ROOT CHORD=*,F5.3,*FT.*,/,50
     1X,*TIP CHORD=*,F5.3,*FT.*,/,50X,*LEADING EDGE SWEEP=*,F5.2,*DEG.*,
     2/,50X,*ROOT THICKNESS=*,F6.4,*FT.*,/,50X,*TIP THICKNESS=*,F6.4,
     3*FT.*,/,50X,*LEADING EDGE RADIUS AT ROOT=*,F6.4,*FT.*,/,50X,
     4*LEADING EDGE RADIUS AT TIP=*,F6.4,*FT.*,/,50X,*DEFLECTION ANGLE*
     5,F5.2,*DEGS.*,///)
  140 READ(5,57) GAC(1),GAC(2),GAC(3),GAC(4),CRC,CTC,BC,CR1C,CR2C,RRC,
     1RTC,TRC,TTC,XOC1,RTEC,IC
      IF(GAC(1).LE.1.) GAC(1)=1.
      IF(CRC.LE.0.0001) GO TO 59
      IF(IC.EQ.2) GO TO 68
      WRITE(6,69)
   69 FORMAT(//,20X,*CANARD GEOMETRY(DOUBLE WEDGE OR MODIFIED DOUBLE WED
     1GE AIRFOIL DESIGN)*,//)
      DTEC=2.*RTEC
      WRITE(6,71) BC,CRC,CTC,GAC(1),GAC(2),GAC(3),GAC(4),CR1C,CR2C,
     1TRC,TTC,RRC,RTC,DTEC,DELTAC
      GO TO 59
   68 WRITE(6,70)
   70 FORMAT(//,40X,*CANARD GEOMETRY(BICONVEX AIRFOIL DESIGN)*,//)
      WRITE(6,66) BC,CRC,CTC,GAC(1),TRC,TTC,RRC,RTC,DELTAC
   59 IF(AM(J).LT.1.049) GO TO 141
      CALL WING(GAW,CRW,CTW,BW,CR1W,CR2W,RRW,RTW,TRW,TTW,MW,IW)
      IF(NTYPE.EQ.4) AREF1=BW/2.*(CRW+CTW)
      ARW=2.*BW/(CRW+CTW)
      CAWW(J)=(4.*SUM3+CABLW)/AREF1
      AB1=ABS(1.05-AM(J))
```

```
      IF(AB1.LT.0.001) CA10=CAWW(J)
      GO TO 142
141   IF(AM(J).GT.0.84) GO TO 143
      CAWW(J)=0.
      GO TO 142
143   CAWW(J)=5.*CA10*(AM(J)-0.85)
142   CR=CRW
      CT=CTW
      CALL SKINFW
      CAFW(J)=CAFWI/AREF1
      IF(RRW.LE.0.00001) GO TO 152
      RTEW1=RTEW*RTW/RRW
      GO TO 153
152   RTEW1=RTEW
153   CALL BASEPW(RTEW,RTEW1,CABW)
      CABW1(J)=CABW/AREF1
      MC=2
      IF(AM(J).LT.1.049) GO TO 144
60    CALL WING(GAC,CRC,CTC,BC,CR1C,CR2C,RRC,RTC,TRC,TTC,MC,IC)
      CAWC(J)=(4.*SUM3+CABLW)/AREF1
      IF(AB1.LT.0.001) CA20=CAWC(J)
      GO TO 145
144   IF(AM(J).GT.0.84) GO TO 146
      CAWC(J)=0.
      GO TO 145
146   CAWC(J)=5.*CA20*(AM(J)-0.85)
145   CR=CRC
      CT=CTC
      BW1=BW
      BW=BC
      CALL SKINFW
      CAFC(J)=CAFWI/AREF1
      IF(RRC.LE.0.00001) GO TO 150
      RTEC1=RTEC*RTC/RRC
      GO TO 151
150   RTEC1=RTEC
151   CALL BASEPW(RTEC,RTEC1,CABC)
      CABC1(J)=CABC/AREF1
      BW=BW1
      IF(NTYPE.EQ.4) GO TO 5
62    CALL GEOM
      AM(J)=VOVS
      IF(J.GT.1) GO TO 17
10    IF(N1.NE.2) GO TO 17
      THEC=ATAN(RP(1))
      THETA=THEC*57.29583
      WRITE(6,30) THETA
30    FORMAT(1X,17HCONE HALF ANGLE =,F10.5,/)
17    CONTINUE
      CALL SKINF
      CALL BASEP
      CALL PBAND
      IF(AL.LT.0.0001) GO TO 18
      IF(VOVS.LT.1.2) CALL NORMFO
18    IF(VOVS.GE.0.81) GO TO 19
```

```
      ICT=NN1
      IF(NSHAPE.EQ.3) ICT=NN2
      IF(NSHAPE.EQ.5) ICT=NN2
      THE1=ATAN(RBP(ICT))*57.293
      IF(THE1.GE.10.) GO TO 51
      CAW=0.
      GO TO 5
   51 CAW=0.012*(THE1-10.)
      GO TO 5
   19 IF(VOVS.LT.1.19) GO TO 2
      CALL HYBRID
      GO TO 5
    2 CALL TRANS
    5 CA=CAF+CAB+CAW+CAP
   61 CA1(J)=CA
      CAF1(J)=CAF
      CAB1(J)=CAB
      CAW1(J)=CAW
      CAP1(J)=CAP
      XT=0.
      IF(NTYPE.EQ.4) GO TO 52
      XT=XB(NN)+RR
      CALL INTERP(ALOD,ETA,XT,ETA1,7,3)
      AREF=3.14159*RREF**2
      AMC1=VOVS*SIN(AL)
      CALL INTERP(AMC,CDC,AMC1,CDC1,9,3)
      CNV=CDC1*ETA1*AP*AL**2/AREF
      CMV=-ETA1*CDC1*AP*AL**2*XP/(AREF*2.*RREF)
      IF(AL.GT.0.0175) GO TO 52
      CNV=0.
      CMV=0.
   52 CN(J)=CNF+CNB+CNW+CNP+CNV
      IF(NTYPE.EQ.1) GO TO 164
      IOP=2
      IOP1=1
      IF(NTYPE.EQ.3) IOP1=2
      K11=K11+1
      CALL LIFT(BW,GAW(1),CRW,CTW,XW,XT,DELTAW,IOP,IOP1,TRW,TTW,KOH,
     1AREF1,DW)
      IF(NTYPE.NE.3) GO TO 164
      IOP=1
      CALL LIFT(BC,GAC(1),CRC,CTC,XC,XT,DELTAC,IOP,IOP1,TRC,TTC,KOH,
     1AREF1,DC)
  164 CM(J)=CMF+CMB+CMW+CMP+CMV
      IF(VOVS.LT.1.19) KOH=KOH+1
      CNWI(J)=CNRF
      CNWB(J)=CNTB
      CNBW(J)=CNBT
      CMWI(J)=CMRF
      CMBW(J)=CMBT
      CMWB(J)=CMTB
      CMCA(J)=CMC
      CNCB(J)=CNFB
      CNBC(J)=CNBF
      CNCA(J)=CNC
```

```
      CMCB(J)=CMFB
      CMBC(J)=CMBF
      CNCW(J)=CNTV
      CMCW(J)=CMTV
      CM(J)=CMF+CMB+CMW+CMP+CMV
      CA2(J)=CAFW(J)+CABW1(J)+CAWW(J)+CNWB(J)*ABS(SIN(DELTAW/57.295))
      CA3(J)=CAFC(J)+CABC1(J)+CAWC(J)+CNCB(J)*ABS(SIN(DELTAC/57.295))
      CAT(J)=CA+CA2(J)+CA3(J)
      CNT(J)=CN(J)+                    CNWB(J)+CNBW(J)+CNCB(J)+CNBC(J)+
     1CNCW(J)
      CMT(J)=CM(J)+                    CMWB(J)+CMBW(J)+CMCB(J)+CMBC(J)+
     1CMCW(J)+CNT(J)*XCG
      CD(J)=CNT(J)*SIN(AL)+CAT(J)*COS(AL)
      CL(J)=CNT(J)*COS(AL)-CAT(J)*SIN(AL)
      IF(ABS(AL).LT.0.0001) GO TO 1
      CNAL(J)=CNT(J)/AL
      CMAL(J)=CMT(J)/AL
      XCP(J)=-CMT(J)/CNT(J)
    1 CONTINUE
      WRITE(6,8)
    8 FORMAT(//,53X,*BODY AXIAL FORCE CONTRIBUTIONS*,//,1X,*MACH NO.*,
     114X,                                                        *SK
     1IN FRICTION*,14X,*BASE PRESSURE*,13X,*PRESSURE*,14X,*PROTRUSIONS*
     2,14X,*TOTAL*,//)
      DO 31 L=1,MN
      WRITE(6,9) AM(L),CAF1(L),CAB1(L),CAW1(L),CAP1(L),CA1(L)
    9 FORMAT(3X,F6.3,18X,F6.4,20X,F6.4,17X,F6.4,16X,F6.4,17X,F6.4)
   31 CONTINUE
      IF(NTYPE.EQ.1) GO TO 126
      WRITE(6,121)
  121 FORMAT(//,53X,*WING AXIAL FORCE CONTRIBUTIONS*,//,1X,*MACH NO.*,
     114X,*SKIN FRICTION*,14X,*BASE PRESSURE*,13X,*PRESSURE*,14X,
     2*TOTAL*,//)
      DO 122 L=1,MN
      WRITE(6,9) AM(L),CAFW(L),CABW1(L),CAWW(L),CA2(L)
  122 CONTINUE
      IF(NTYPE.NE.3) GO TO 120
      WRITE(6,123)
  123 FORMAT(//,53X,*CANARD AXIAL FORCE CONTRIBUTIONS*,//,1X,*MACH NO.*,
     114X,*SKIN FRICTION*,14X,*BASE PRESSURE*,13X,*PRESSURE*,14X,
     2*TOTAL*,//)
      DO 124 L=1,MN
      WRITE(6,9) AM(L),CAFC(L),CABC1(L),CAWC(L),CA3(L)
  124 CONTINUE
  120 WRITE(6,125)
  125 FORMAT(//,53X,*NORMAL FORCE CONTRIBUTIONS*,//,3X,*MACH NO.*,4X,
     1*BODY ALONE*,4X,*WING ALONE*,2X,*CANARD ALONE*,3X,*WING-BODY*
     2,4X,*BODY-WING*,3X,*CANARD-BODY*,2X,*BODY-CANARD*,2X,
     3*CANARD-WING*,5X,*TOTAL*,//)
      DO 127 L=1,MN
      WRITE(6,128) AM(L),CN(L),CNWI(L),CNCA(L),CNWB(L),CNBW(L),CNCB(L),
     1CNBC(L),CNCW(L),CNT(L)
  127 CONTINUE
  128 FORMAT(1X,10(3X,F7.4,3X))
  126 WRITE(6,12)
```

```
 12   FORMAT(//,53X,*TOTAL STATIC AERODYNAMICS(FORCE/ALPHA)*,//,10X,
     1*MACH NO.*,10X,*CD*,
     110X,*CN*,10X,*CL*,10X,*CM*,10X,*CNAL*,10X,*CMAL*,10X,*XCP/D*,//)
      DO 14  L=1,MN
      WRITE(6,13) AM(L),CD(L),CNT(L),CL(L),CMT(L),CNAL(L),CMAL(L),XCP(L)
 14   CONTINUE
 13   FORMAT(12X,F5.3,9X,F6.4,6X,F6.4,6X,F6.4,6X,F6.3,5X,F7.3,7X,F8.3,
     18X,F7.4)
  27  CONTINUE
      END
```

```
      SUBROUTINE AINTERP(D,C,E,ANSWER,A,B,N,M)
      DIMENSION D(1),C(1),E(N,M)
      DO 100 I=1,N
      IF(A-C(I)) 200,100,100
100   CONTINUE
200   DO 300 J=1,M
      IF(B-D(J)) 400,300,300
300   CONTINUE
400   A1=D(J)-D(J-1)
      B1=B-D(J-1)
      C1=E(I-1,J)-E(I-1,J-1)
      X1=B1*C1/A1
      D1=X1+E(I-1,J-1)
      A2=D(J)-D(J-1)
      B2=B-D(J-1)
      C2=E(I,J)-E(I,J-1)
      X2=B2*C2/A2
      D2=X2+E(I,J-1)
      A3=C(I)-C(I-1)
      B3=A-C(I-1)
      C3=D2-D1
      X3=B3*C3/A3
      ANSWER=X3+D1
      RETURN
      END
```

```
      FUNCTION ARCOSH(Z)
      ARCOSH=ALOG(Z+ SQRT(Z**2-1.))
      RETURN
      END
```

```
      FUNCTION ARCOS(X,Y)
      Z=SQRT(ABS(Y**2-X**2))
      ARCOS=ATAN2(Z,X)
      RETURN
      END
```

```
      FUNCTION ARSECH(Z)
      ARSECH=ALOG(1./Z+SQRT(1./Z**2-1.))
      RETURN
      END
```

```
      FUNCTION ARSIN(X,Y)
      Z=SQRT(ABS(Y**2-X**2))
      ARSIN=ATAN2(X,Z)
      RETURN
      END
```

```
      FUNCTION ARSINH(Z)
      ARSINH=ALOG(Z+SQRT(Z**2+1.))
      RETURN
      END
```

```
      FUNCTION ARTANH(Z)
      ARTANH=.5*ALOG((1.+Z)/(1.-Z))
      RETURN
      END
```

```
      SUBROUTINE BASEP
      COMMON/GEOM/RP(6),X(30),R(30),C2,N,SHAPE,N1,N2,XB(225),RB(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NPLOT,NN,NNI,IPRINT,NSTA
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,NSTA
      COMMON/GEO4/ K,F,RR,RREF
      COMMON/BASE/CAB,CNB,CMB,TOC,XOC,NTYPE
      DIMENSION TCP3D(20),TXM1(20),DCPF(20)
      DATA(TCP3D(I),I=1,19)/.120,.124,.130,.135,.142,.154,.209,.219,.221
     1,.218,.211,.191,.173,.157,.143,.131,.114,.104,.095/
      DATA(TXM1(I),I=1,19)/0.,.5,.7,.8,.85,.90,1.0,1.05,1.1,1.2,1.3,1.5,
     11.7,1.9,2.1,2.3,2.5,2.8,3.0/
      DATA(DCPF(I),I=1,19)/.23,.4,.5,.56,.59,.63,.7,.735,.75,.77,.78
     1,.78,.66,.48,.32,.2,.12,.04,0./
      CNB=C.
      CMB=C.
      FACT=AL*57.295*(RB(NN)/RREF)**3
      CAAW=0.
C     THIS SUBROUTINE CALCULATES BASE DRAG THROUGHOUT THE MACH NUMBER RANGE
      DCPBA=0.
      CALL INTERP(TXM1,TCP3D,VOVS,CP3D,19,3)
      IF(RB(NN).LE.RREF) GO TO 6
      CDBP=CP3D*(RB(NN)/RREF)**2
      GO TO 7
    6 CDBP=CP3D*(RB(NN)/RREF)**3
    7 IF(NTYPE.GT.1) GO TO 2
      IF(AL.LE.0.0175) GO TO 3
      DCPBA=.0085*FACT*(1.+(1.-VOVS)/3.)
    3 CONTINUE
      CAB= CDBP + DCPBA + CAAW
      GO TO 99
    2 DCPBA=(.0035-.01*ABS(XOC))*FACT
      XOC1=0.1*ABS(XOC)
      IF(TOC.GE.XOC1) GO TO 4
      DCPBF=0.
      GO TO 5
    4 CALL INTERP(TXM1,DCPF,VOVS,DCP,19,3)
      DCPBF=DCP*(TOC-XOC1)*(RB(NN)/RREF)**3
    5 CAB=CDBP+DCPBA+DCPBF
   99 RETURN
      END
```

```
      SUBROUTINE BASFPW(RLE,RTE,CABW)
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,NNIA
      COMMON/VOL/VOL,CAF,CNF,CMF,RN,DIA,XP,AP,VOLN,CR,CT,BW,CAFWI
      DIMENSION CP2D(20),XM1(20)
      DATA(CP2D(I),I=1,19)/.28,.293,.299,.31,.325,.345,.46,.466,.465,
     1.44,.405,.337,.285,.245,.213,.186,.165,.135,.115/
      DATA(XM1(I),I=1,19)/0.,.5,.7,.8,.85,.9,1.,1.05,1.1,1.2,1.3,1.5,
     11.7,1.9,2.1,2.3,2.5,2.8,3.1/
      CABW=0.
      IF(CR.LE.0.001) GO TO 99
C     THIS SUBROUTINE CALCULATES TRAILING EDGE SEPARATION DRAG.
      CALL INTERP(XM1,CP2D,VOVS,CPW,19,3)
      CABW=2.*BW*CPW*(RLE+RTE)
   99 RETURN
      END
```

```
      SUBROUTINE BLUNT
      COMMON/GEOM/RP(6),X(30),R(30),C2,N,NSHAPE,N1,N2,XB(225),RB(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NBLUNT,NN,NNI,IPRINT,NN1A
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,NNIA
      COMMON/GEO4/K,F,RR,RBFF
      COMMON/GEO5/ C3
      CALL FD5(X(1),X(1),X(2),X(3),X(4),X(5),R(1),R(2),R(3),R(4),R(5),
     1DR3)
      VOV=VOVS
      IF(VOVS.LE.1.19) VOV=1.0001
      AMU=TAN(ASIN(1./VOV))*F
      IF(DRB.LE.AMU) GO TO 21
      AMU=ATAN(DRB)/F
      VOVS=1./SIN(AMU)
      BETA=SQRT(ABS(VOVS**2-1.))
   21 J=1
      TH1=ATAN(DRB)
      RR=R(1)*COS(TH1)
    2 IF(VOVS.GT.2.1) GO TO 14
      THET1=27.5/57.295
      D=TAN(THET1)
      IF(D.LT.DRB) D=DRB
      THET1=ATAN(D)
      XM=-RR*SIN(THET1)
      YM= RR*COS(THET1)
      XB(1)=XM-YM/TAN(THET1)
      GO TO 15
   14 YM=RR*BETA/VOVS
      XM=-RR/VOVS
      XB(1)=RR**2/XM
      THE  =ATAN(YM/(XM-XB(1)))
      THET1=THE*F
      XM=-RR*SIN(THET1)
      YM= RR*COS(THET1)
      XB(1)=XM-YM/TAN(THET1)
   15 RP(1)=TAN(THET1)
      THE=THET1*57.295
      RB(1)=0.
      XB(2)=XM
      RB(2)=YM
      RBP(1)=TAN(THET1)
      RBP(2)=RBP(1)
      Z=SQRT(1.+DR3**2)
      XI=-DR3*RR/Z
      RI=RR/Z
      XINT=XI
      YINT=RI
      XIXM=ABS(XI-XM)
      NNIA=2
      IF(XIXM-.001) 13,13,19
   13 K=1
      NN1=2
      GO TO 16
   19 E=16./VOV**2
```

```
      IF(E.LT.2.5) E=2.5
      XB(3)=XB(2)+.01/VOV **E*RB(2)*(THE/30.)**2
      DO 3 K=3,150
      A=K-2
      RB(K)=SQRT(RR**2-XB(K)**2)
      XB(K+1)=XB(K)+.01/VOV **E*RB(K)*A**0.50*(THE/30.)**2
      RBP(K)=-XB(K)/RB(K)
      IF(XB(K+1).GE.XI) GO TO 10
    3 CONTINUE
   10 XB(K+1)=XI
      RB(K+1)=RI
      RBP(K+1)=DRB
      IF(NN1A.EQ.2) GO TO 16
      NN1=K+1
      NN2=NN1+10
      K=K+1
      XB(K+1)=XI
      RB(K+1)=RI
      RBP(K+1)=RBP(K)
      IF(NFL.EQ.2) NNI=K+1
      IF(RI.GE.RR) GO TO 99
   16 DX=-XI/6.
      DR=(R(1)-RI)/6.
      DO 13 J=1,5
      K=K+1
      XB(K+1)=XB(K)+DX
      RB(K+1)=RB(K)+DR
      RBP(K+1)=DRB
   13 CONTINUE
      IF(NFL.EQ.2) NNI=K+1
      IF(NFL.EQ.2) NN2=K+1
      IF(NN1A.EQ.1) GO TO 99
      K=K+1
      IJ=1
      XB(K+1)=X(1)
      RB(K+1)=R(1)
      CALL FDP5(X,R,XB(K+1),RBP(K+1),N1,1)
   20 BET1=BETA
      IF(BET1.GT.1.) BET1=1.
      K=K+1
      XB(K+1)=XB(K)+C3*BET1*RB(K)
      CALL INTERP(X,R,XB(K+1),RB(K+1),N1,3)
      CALL FDP5(X,R,XB(K+1),RBP(K+1),N1,1)
   17 K=K+1
      IJ=IJ+1
      A=IJ
      C5=A*C3
      BET1=BETA
      IF(BET1.GT.1.) BET1=1.
      XB(K+1)=XB(K)+C5*BET1*RB(K)
      IF(XB(K+1).GE.X(N1)) XB(K+1)=X(N1)
      CALL INTERP(X,R,XB(K+1),RB(K+1),N1,3)
      CALL FDP5 (X,R,XB(K+1),RBP(K+1),N1,1)
      IF(XB(K+1).LT.(X(N1)-.0001)) GO TO 17
      IJ=1
```

```
      XR(K+1)=X(N1)
      PR(K+1)=P(N1)
      CALL FDP5(X,P,XR(K+1),PRP(K+1),N1,1)
      NN1=K+1
      GO TO 99
   99 RETURN
      END
```

```
      SUBROUTINE  CP3DW
      COMMON/GEO1/ RBP(225),BETA
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,CABLW
      COMMON/CPWING/ TGA(70),ETA(70),AMU,XP,XO(70),YP,DZDX(70),XT(70),IL
      DIMENSION SIG(70),XMA(70),XGA(70)
      PI=3.1415927
      B1=SUM6
      YI=       (XT(1)+BETA*B1/2.-XO(IL  ))/(TGA(IL)+BETA)
      DO 1 J=1,IL
      AB=ABS(XP-XO(J))
      IF(AB.LT.0.0000001) GO TO 25
    7 SIG(J)=TGA(J)*YP/(XP-XO (J))
      GO TO 26
   25 SIG(J)=1.
   26 XMA(J)=YP    /TAN(AMU) +XO(J)
      XGA(J)=TGA(J)*YP     +XO(J)
      X1=YP*TGA(1)+XO(1)
      XG=XGA(J)-X1
      XM=XMA(J)-X1
      XPP=XP-X1
      IF(XMA(J).GE.XGA(J)) GO TO 2
      IF(XP.GE.XMA(J)) GO TO 3
      GO TO 1
    3 IF(XP.GE.(XGA(J)-0.0001)) GO TO 6
      IF(SIG(J).LE.1.00001) SIG(J)=1.00001
   28 A=PI*BETA*SQRT(ETA(J)**2-1.)
      B=SQRT((ETA(J)**2-1.)/(SIG(J)**2-1.))
      PHEX=-2.*(DZDX(J+1)-DZDX(J))/A*ARCOSH(B)
      SUM1=SUM1+PHEX
      IF(YP.LT.YI) GO TO 1
      XIJ=XT(J)+BETA*(B1/2.-YP)
      IF(XP.LT.XIJ) GO TO 1
      SI=TGA(J)*(B1/2.-YP)/(XP-XT(J))
      B2=(ETA(J)**2+SI)/(1.+SI)/ETA(J)
      IF(B2.LE.1.00001) B2=1.00001
      PHEXT= (DZDX(J+1)-DZDX(J))/A*ARCOSH(B2)
      SUM1=SUM1+PHEXT
      GO TO 1
    6 A=SQRT(ETA(J)**2-1.)*PI*BETA
      IF(SIG(J).GE.0.999990) SIG(J)=.999990
   30 B=SQRT((ETA(J)**2-SIG(J)**2)/(1.-SIG(J)**2))
      PHEX=-2.*(DZDX(J+1)-DZDX(J))/A*ARCOSH(B)
      SUM1=PHEX +SUM1
      IF(YP.LT.YI) GO TO 1
      XIJ=XT(J)+BETA*(B1/2.-YP)
      IF(XP.LT.XIJ) GO TO 1
      SI=TGA(J)*(B1/2.-YP)/(XP-XT(J))
      B2=(ETA(J)**2+SI)/(1.+SI)/ETA(J)
      IF(B2.LE.1.00001) B2=1.00001
      PHEXT= (DZDX(J+1)-DZDX(J))/A*ARCOSH(B2)
      SUM1=SUM1+PHEXT
      GO TO 1
    2 IF(XP.GE.(XGA(J)-0.0001)) GO TO 4
      GO TO 1
    4 IF(XP.GE.XMA(J)) GO TO 5
```

```
      A=SQRT(1.-ETA(J)**2)*BETA
      PHEX=-(DZDX(J+1)-DZDX(J))/A
      SUM1=SUM1+PHEX
      IF(YP.LT.YI) GO TO 1
      XIJ=XT(J)+BETA*(B1/2.-YP)
      IF(XP.LT.XIJ) GO TO 1
      SI=TGA(J)*(B1/2.-YP)/(XP-XT(J))
      B2=(SI+ETA(J)**2)/(ETA(J)*(1.+SI))
      IF(B2.GE.0.999990) B2=0.999990
      PHEXT=(DZDX(J+1)-DZDX(J))/(A*PI)*ACOS(B2)
      SUM1=SUM1+PHEXT
      GO TO 1
    5 A=PI*BETA*SQRT(1.-ETA(J)**2)
      IF(SIG(J).GE.0.999990) SIG(J)=.999990
      B=SQRT((ETA(J)**2-SIG(J)**2)/(1.-SIG(J)**2))
      PHEX=-(DZDX(J+1)-DZDX(J))/A*(PI-2.*ASIN(B))
      SUM1=SUM1+PHEX
      IF(YP.LT.YI) GO TO 1
      XIJ=XT(J)+BETA*(B1/2.-YP)
      IF(XP.LT.XIJ) GO TO 1
      SI=TGA(J)*(B1/2.-YP)/(XP-XT(J))
      B2=(ETA(J)**2+SI)/(1.+SI)/ETA(J)
      IF(B2.GE.0.999990) B2=0.999990
      PHEXT= (DZDX(J+1)-DZDX(J))/A*ACOS(B2)
      SUM1=SUM1+PHEXT
      GO TO 1
    1 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DISC1
      COMMON/GEOM/RP(6),X(30),P(30),C2,N,NSHAPE,N1,N2,XB(225),RB(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NBLUNT,NN,NNI,IPRINT,NN1A
      COMMON/DISC/I,JK,AI2,SUM,JH,PI
      COMMON/DAT1/ T(100),AK(100),AE(100),C(225),C1(225),C3
      D=ABS(RBP(JH)-RBP(JH-1))
      XI=XB(JH)-BETA*RB(JH)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.9999999
      CALL INTERP(T,AK,TAU,AKX,100,3)
      CALL INTERP(T,AE,TAU,AEX,100,3)
C     CURVATURE SOLUTION FOR FIRST ORDER FUNCTION
      THR2=C(JH)*BETA*SQRT(XB(I)-XI)*4./3.*SQRT(2.)/PI*SQRT(1.+TAU)*
     1(AEX/TAU-AKX)*SQRT(BETA*RB(JH))
      HALF=0.
      IF(D.LE.0.0001) GO TO 98
      HALF=C(JH)*2.*BETA/PI*SQRT(RB(JH )/RB(I))*SQRT(2.*TAU/(1.+TAU))*
     1((1.+TAU)/TAU*AEX-AKX)
   98 SUM=SUM+THR2+HALF
      RETURN
      END
```

```
      SUBROUTINE DISC2
      COMMON/GEOM/PP(6),X(30),P(30),C2,N,NCHAN,N1,N2,XB(225),RB(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/DAT1/ T(100),AK(100),AE(100),C(225),C1(225),C3
      COMMON/DISC/T,JK,AI2,SUM,JH,PI
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,CABLW
C     CURVATURE SOLUTION.
      XI=XB(JH)-BETA*RB(JH)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.9999999
      CALL INTERP(T,AK,TAU,AKX,100,3)
      CALL INTERP(T,AE,TAU,AEX,100,3)
      A=SQRT(XB(I)-XI)
      B=SQRT(1.+TAU)
      D=2./PI*SQRT(2.        )
      A1=C(JH)*SQRT(BETA*RB(JH))
      B1=SQRT((1.+TAU)*RB(I)/(TAU*RB(JH)))
      SUM1=SUM1-A1    *A**1.5*4./9.*D*B*((3.+TAU)*AKX-4.*AEX)
      SUM2=SUM2-A1    *A*2.*D*B*(AKX-AEX)
      SUM3=SUM3+A1    *BETA*A*2./3.*D*B*(AEX/TAU-AKX)
      SUM4=SUM4-A1    /A*D*AKX/B
      SUM5=SUM5+A1    *BETA/A*D/B*((1.+TAU)/TAU*AEX-AKX)
      SUM6=SUM6-A1    *BETA**2/A*D/B*(2.*(1.+TAU)/TAU**2*AEX-(2.-TAU)/
     1TAU*AKX)/3.
      E=ABS(RBP(JH)-RBP(JH-1))
      IF(E.LT.0.0001) GO TO  99
C     CORNER SOLUTION
      A2=A**2
      F=SQRT(RB(JH)/RB(I))/PI
      G=SQRT(2.*TAU)/B
      IF(TAU.GT.0.999) GO TO 2
      H=1./(1.-TAU)
    2 H1=C(JH)
      SUM1 = SUM1-H1*4.*A2*F*B**2*G*(AKX-AEX)
      SUM2 = SUM2-H1*2.*F*G*AKX
      SUM3 = SUM3+H1*2.*BETA*F*G*(B**2*AEX/TAU-AKX)
      IF(TAU.LT.0.999) GO TO 1
      SUM4=SUM4+H1/(8.*BETA*RB(JH))
      SUM5=SUM5+3.*H1/(8.*RB(JH))
      SUM6=SUM6-7.*BETA*H1/(8.*RB(JH))
      GO TO 99
    1 SUM4 = SUM4+H1*F/A2*H*G*(AKX-AEX)
      SUM5 = SUM5+H1*BETA*F/A2*H*G*(AEX/TAU-AKX)
      SUM6 = SUM6-H1*BETA**2/A2*F*H*G*((2.-TAU**2)/TAU**2*AEX-(2.-TAU)
     1/TAU*AKX)
   99 RETURN
      END
```

```
      SUBROUTINE DISC3
      COMMON/GEOM/RP(6),X(30),R(30),C2,N,NSHAPE,N1,N2,XB(225),RB(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/DAT1/ T(100),AK(100),AE(100),C(225),C1(225),C3
      COMMON/DISC/I,JK,AI2,SUM,JH,PI
      D=ABS(RBP(JH)-RBP(JH-1))
      XI=XB(JH)-BETA*RB(JH)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.9999999
      CALL INTERP(T,AK,TAU,AKX,100,3)
      CALL INTERP(T,AE,TAU,AEX,100,3)
C     CURVATURE SOLUTION FOR COMPLIMENTARY FUNCTION
      A=SQRT(2.*TAU*RB(JH)/(RB(I)*(1.+TAU)))
      B=C1(JH)*BETA/PI*SQRT(BETA*RB(JH))
      SUM=SUM+2.*BETA*C1(JH)/PI*A*((1.+TAU)/TAU*AEX-AKX)
      IF(D.LE.0.0001) GO TO 99
C     CORNER SOLUTION FOR COMPLIMENTARY FUNCTION
      B1=-C3*BETA/PI
      IF(TAU.GT.0.995) GO TO 1
      SUM1=B*SQRT(XB(I)-XI)*4./3.*SQRT(2.*(1.+TAU))*(AEX/TAU-AKX)
      SUM2=B1/(XB(I)-XI)*A/(1.-TAU)*(AEX/TAU-AKX)
      GO TO 2
    1 SUM1=0.
      SUM2=-3.*C3    /(8.*RB(I))
    2 SUM=SUM+SUM1+SUM2
   99 RETURN
      END
```

```
      SUBROUTINE DISC4
      COMMON/GEOM/PP(6),X(30),R(30),C2,N,NS-APE,N1,N2,XB(225),RB(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/DAT1/ T(100),AK(100),AE(100),C(225),C1(225),C3
      COMMON/DISC/I,JK,AI2,SUM,JH,PI
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,CABLW
C     CURVATURE SOLUTION
      XI=XB(JH)-BETA*RB(JH)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.9999999
      CALL INTERP(T,AK,TAU,AKX,100,3)
      CALL INTERP(T,AE,TAU,AEX,100,3)
      A=SQRT(XB(I)-XI)
      B=SQRT(1.+TAU)
      D=2.**1.5/PI
      E=ABS(RBP(JH)-RBP(JH-1))
      F=SQRT(RB(JH)/RB(I))/PI
      G=SQRT(2.*TAU)/B
      A2=A**2
      H1=C1(JH)*F*G
      SUM1=SUM1-H1*4.*A2*B**2*(AKX-AEX)
      SUM2=SUM2-H1*2.*AKX
      SUM3=SUM3+H1*2.*BETA*(B**2*AEX/TAU-AKX)
      IF(E.LT.0.0001) GO TO 2
C     CORNER SOLUTION
      H2=C1(JH)*D*B*SQRT(BETA*RB(JH))
      SUM1=SUM1-H2*A**1.5*4./9.*((3.+TAU)*AKX-4.*AEX)
      SUM2=SUM2-H2*A*2.*(AKX-AEX)
      SUM3=SUM3+H2*BETA*A*2./3.*(AEX/TAU-AKX)
      SUM1=SUM1+C3    *2.*G*F*AKX
      IF(TAU.LT.0.995) GO TO 1
      SUM2=SUM2-C3    /(8.*BETA*RB(JH))
      SUM3=SUM3-3.*C3    /(8.*RB(JH))
      GO TO 2
    1 H=1./(1.-TAU)
      SUM2=SUM2-C3    /A2*F*H*G*(AKX-AEX)
      SUM3=SUM3-C3    *BETA/A2*F*H*G*(AEX/TAU-AKX)
    2 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DIST (X1,X2,S)
      DIMENSION DISXCP(11),DCCL(11),XCP4(4)
      DIMENSION X1(10,10),X2(10,10),S(20),PX(10),HX(10),XR1(10),XR2(10),
     $          ALOAD(30),XCP(30),MOMENT(30),D(10)
      COMMON/AERO3/H1(10,10),HH1(10)
      COMMON/AERO5/GN1(10,10),GN2(10,10)
      COMMON/AERO8/NB,NA,MYFS,X,IWING
      COMMON/AERO9/N1,N2,N4
      COMMON/AERO10/SPAN,CR,CT,OMEGA,PSS
      COMMON/AERO11/SAREA,ALPHAWB,CLT,BETAM
      COMMON/ANAME/ROLL,PITCH,MACH,ALPHA,RC,XCG,DIHED
      COMMON/Z/XLE(4),XTE(4),Y(4),GAMA,XCPF
      REAL MACH
      REAL MOMENT
      BETA=SQRT(ABS(1.-MACH**2))
      PX(1)=0.05
      PX(2)=0.1
      DO 721 I=3,10
      PX(I)=PX(I-1)+0.1
  721 CONTINUE
      KI=0
      LK=0
      LKS=N1
      N5=N1+N2
      DO 500 K=1,10
      XR1(K)=0.
      XR2(K)=0.
      DO 501 I=1,N4
      HX(I)=0.
      DO 501 J=1,N4
  501 HX(I)=HX(I)+H1(J,I)*PX(K)**(J-1)*SQRT((1.-PX(K))/PX(K))
      DO 500 J=1,N1
      DO 500 I=1,N4
      XR1(K)=XR1(K)+GN1(1,J)*X1(I,J)*HX(I)
  500 XR2(K)=XR2(K)+GN2(1,J)*X2(I,J)*HX(I)
      DO 604 J=1,N1
      CM1=0.
      CM2=0.
      HST1=0.
      HST2=0.
      X=-0.00001
      DO 40 L=1,49
      X=X+0.02
      XD1=0.
      XD2=0.
      CALL HINT
      DO 603 I=1,N4
      XD1=XD1+HH1(I)*X1(I,J)
  603 XD2=XD2+HH1(I)*X2(I,J)
      CM1  =(XD1-HST1)*(X-0.01)+CM1
      CM2  =(XD2-HST2)*(X-0.01)+CM2
      HST1=XD1
   40 HST2=XD2
      LK=LK+1
      LKS=LK+N1
```

```
      ALOAD(LK)=HST1
      ALOAD(LKS)=HST2
      HQ(LK)=CM1
      HQ(LKS)=CM2
      XCP(LK)=CM1/(HST1+0.000001)
  604 XCP(LKS)=CM2/(HST2+0.000001)
      DO 5000 III=1,4
      XCP4(III)=XCP(III)
 5000 CONTINUE
      JSURF=1
      JSURF=2
      DO 105 K=1,10
      K2=K+10
      MOMENT(K)=0.
      MOMENT(K2)=0.
      XR1(K)=0.
      XR2(K)=0.
      DO 105 I=1,N1
      N=I+N1
      DO 105 J=1,N1
      MOMENT(K)=MOMENT(K)+GN1(J,I)*HQ(I)*PX(K)**(J-1)*SQRT(1.-PX(K))
      MOMENT(K2)=MOMENT(K2)+GN2(J,I)*HQ(N)*PX(K)**(J-1)*SQRT(1.-PX(K))
      XR1(K)=XR1(K)+GN1(J,I)*ALOAD(I)*PX(K)**(J-1)*SQRT(1.-PX(K))
  105 XR2(K)=XR2(K)+GN2(J,I)*ALOAD(N)*PX(K)**(J-1)*SQRT(1.-PX(K))
      S1=PSS*SPAN/2.
      CP=2.*S1*(1.-CT/CR)/SPAN
      CS=1.-CT/CR
      DO 5 K=1,10
      K2=K+10
      XCP(K)=CR*(1.-CP*PX(K))*BETAM*MOMENT(K)/XR1(K)
    5 XCP(K2)=CR*(1.-CS*PX(K))*BETAM*MOMENT(K2)/XR2(K)
      DO 3 K=1,10
      XR1(K)=CR*XR1(K)*(1.-CP*PX(K))
    3 XR2(K)=CR*XR2(K)*(1.-CS*PX(K))
      JSURF=1
      JSURF=2
      SUM1=0.05*XR1(1)
      SUM2=0.05*XR2(1)
      DO 99 I=2,10
      SUM1=SUM1+XR1(I)*0.1
      SUM2=SUM2+XR2(I)*0.1
   99 CONTINUE
      SUM1=SUM1*S(1)
      JK=N1+N2
      SUM2=SUM2*S(JK)
      JSURF=1
      JSURF=2
      CLT=(SUM1+SUM2)/SAREA
      DCLDA=CLT/ALPHAWR
      DY=SPAN/20.
      CALL SUBXCP(SPAN,BETA,DISXCP,XCP4)
      CCLRT=-(2.*XR1(1)-XR1(2))
      DO 53 I=1,10
      IF(I-1) 51,51,52
   51 CCCL(1)=CCLRT
```

```
      GO TO 53
   52 DCCL(I)=-XR1(I)
   53 CONTINUE
      DCCL(11)=0.
      CMWING=DY/(3.*SAREA)*(DCCL(1)*DISXCP(1)+4.*DCCL(2)*DISXCP(2)+2.*DC
     1CL(3)*DISXCP(3)+4.*DCCL(4)*DISXCP(4)+2.*DCCL(5)*DISXCP(5)+4.*DCCL(
     26)*DISXCP(6)+2.*DCCL(7)*DISXCP(7)+4.*DCCL(8)*DISXCP(8)+2.*DCCL(9)*
     3DISXCP(9)+4.*DCCL(10)*DISXCP(10)+DCCL(11)*DISXCP(11))*2.
      XCPF=-CMWING/CLT
      RETURN
      END
```

```
      SUBROUTINE FLIPT1(ARG,ANS)
      DIMENSION TEOFK(5),THETA(5)
      DATA(THETA(I),I=1,5)/0.,20.,40.,70.,90./
      DATA(TEOFK(I),I=1,5)/1.5708,1.5238,1.3931,1.1184,1./
      CALL INTERP(THETA,TEOFK,ARG,ANS,5,3)
      RETURN
      END
```

```
      SUBROUTINE FLIPT2(ARG,ANS)
      DIMENSION TFOFK(23),THETA(23)
      DATA(THETA(I),I=1,23)/0.,10.,20.,30.,40.,50.,60.,70.,75.,80.,85.,
     186.,87.,88.,89.,89.4333,89.6667,89.75,89.8333,89.9167,89.95,89.966
     27,89.9833/
      DATA(TFOFK(I),I=1,23)/1.5708,1.5828,1.62,1.6858,1.7868,1.9356,2.15
     165,2.5046,2.7681,3.1534,3.8317,4.053,4.339,4.743,5.435,6.003,6.533
     2,6.821,7.226,7.919,8.43,8.836,9.529/
      CALL INTERP(THETA,TFOFK,ARG,ANS,23,3)
      RETURN
      END
```

```
      SUBROUTINE FRINT(R,B,VOVS,CR,CT,AP,CLAMDA,CLA,XKWB,XKBW,XKWB1,XKBW
     11,XL,XLE,APEF)
C     THIS SUBROUTINE CALCULATES THE FIN-BODY AND BODY-FIN INTERFERENCE
C     THROUGH THE ENTIRE MACH NUMBER RANGE. XKBW IS THE LIFT OF THE BODY
C     IN THE PRESENCE OF THE WING DIVIDED BY THE LIFT OF THE WING ALONE
C     DUE TO ANGLE OF ATTACK. XKWB IS THE LIFT OF THE WING IN THE PRESEN
C     CE OF THE BODY DIVIDED BY THE LIFT OF THE WING ALONE DUE TO ANGLE
C     OF ATTACK.
C     XKWB1 IS THE LIFT OF THE WING IN THE PRESENCE OF THE BODY DIVIDED
C     BY THE LIFT OF THE WING ALONE DUE TO WING DEFLECTION.
C     XKBW1 IS THE LIFT OF THE BODY IN THE PRESENCE OF THE
C     WING DIVIDED BY THE LIFT OF THE WING ALONE DUE TO WING DEFLECTION.
C     SLAMDA EQUALS FIN TAPER RATIO
C     CLAMDA EQUALS LEADING EDGE SWEEP ANGLE
C     B IS THE SIMISPAN OF THE FIN EXTENDED TO THE BODY CENTERLINE
C     LOP EQUAL 1 NO AFTERBODY PRESENT BEHIND FIN
C     LOP1 EQUAL 1 NO FIN DEFLECTION
      F=CR/((B-R)*TAN(CLAMDA/57.29578)+CT)
      CRN=XLE+CR-XL
      IF(CRN.GT.0.001) F=(CR-CRN)/((B-R)*TAN(CLAMDA/57.29578)+CT)
      IF(VOVS.EQ.1.) VOVS=.9999998
      XKBW11=2.
      LOP=2
      XKWB1=0.
      XKBW1=0.
      BETA=SQRT(ABS(VOVS**2-1.))
      DF=2.*R
      XL1=XLE+CR+DF*BETA
      XL2=XLE+CR
      IF((XL-0.01).LE.XL2) LOP=1
      IF(XL-XL1) 500,500,600
  500 XAFT=XL-(XLE+CR)
      GO TO 601
  600 XAFT=DF*BETA
  601 A1=DF*BETA
      A2=XAFT
      BDCR=2.*BETA*R/CR
      SLAMDA=CT/CR
      IF(CLAMDA.LE.0.) GO TO 5072
      XM=1./(TAN(CLAMDA/57.29578))
      BXM=BETA*XM
      GO TO 87
 5072 BXM=1000.
   87 CONTINUE
      FACTOR=BETA*AP*(1.+SLAMDA)*(1./BXM+1.)
      IF(BXM.LT.0.01) FACTOR=0.
      RB=R/B
      SW=(B-R)*(CR+CT)
      FACT1=BETA*CLA*(1.+SLAMDA)*(1./RB-1.)*APEF/SW
      IF(RB.LE.0.) GO TO 22
      IF(RB.GE.1.) GO TO 23
      XK1=2./(3.14159*(1.-RB)**2)
      XK2=1.+RB**4
      XK3=.5*ATAN(.5*(1./RB-RB))
      XK4=3.14159/4.
```

```
      XK5=RB**2
      XK6=1./RB-RB
      XK7=2.*ATAN(RB)
      XKWB=XK1*(XK2*(XK3+XK4)-XK5*(XK6+XK7))
      GO TO 24
   22 XKWB=1.
      GO TO 24
   23 XKWB=2.
   24 CONTINUE
    1 XKBW=(1.+RB)**2-XKWB
      XKBW11=XKBW
      XKBWNA=XKBW
      XKBWA=XKBW
      IF(VOVS.LT.1.) GO TO 50
      IF(FACTOR.LE.2.0) GO TO 50
    3 C1=1./BDCR
      IF(C1.LE.1.) C1=1.
      XMCROD=C1*BXM
      IF(BXM-1.)4,4,5
    4 XK1=16.*SQRT(BXM)/3.14159/(BXM+1.)/C1
      XK2=(1.+XMCROD)*SQRT((C1-1.)*(XMCROD+1.))
      XK3=C1**2*BXM**(1.5)
      XK4=BXM*C1**2*(BXM+1.)
      XK5=ATAN(SQRT(1./BXM))-ATAN(SQRT((C1-1.)/(XMCROD+1.)))
      XK6=(BXM+1.)/SQRT(BXM)*ARTANH(SQRT(BXM*(C1-1.)/(XMCROD+1.)))
      XKBW=XK1*(XK2-XK3+XK4*XK5-XK6)
      GO TO 12
    5 XK1=8./(3.14159*SQRT(BXM**2-1.))/C1
      XK2=(1.+XMCROD)**2*ARCOS((BXM+C1),(1.+XMCROD))
      XK3=C1**2*ARCOS(1.,BXM)*BXM**2
      XK4=BXM*C1**2*SQRT(BXM**2-1.)*ARSIN(1.,C1)
      XK5=SQRT(BXM**2-1.)*ARCOSH(C1)
      XKBW=XK1*(XK2-XK3+XK4-XK5)
   12 CONTINUE
      IF(C1.EQ.1.) XKBW=XKBW/BDCR
      XKBW=XKBW/FACT1
      IF(XKBW.GT.XKBW11) XKBW=XKBW11
      XKBWNA=XKBW
    7 XMCROD=1./(BDCR/BXM)
      C1=1./BDCR
      C2=BXM/(1.+BXM)
      C3=1./C2
      C4=1.+C3*BDCR
      IF(BXM-1.)8,8,9
    8 XK1=16.*C2**2/(3.14159*BDCR)
      XK2=C4**(1.5)
      XK3=SQRT(C4)
      XK4=(C3*BDCR)**2*ARTANH(SQRT(1./C4))
      XKBW=XK1*(XK2+XK3-2.-XK4)
      GO TO 14
    9 XK1=8.*BXM/(3.14159*SQRT(BXM**2-1.)*BDCR)
      XK2=C2*C4**2*ARCOS((1.+(1.+BXM)*BDCR),(C4*BXM))
      XK3=SQRT(BXM**2-1.)/(BXM+1.)*(SQRT(1.+2.*BDCR)-1.)
      XK4=SQRT(BXM**2-1.)/BXM*BDCR**2*ARCOSH(1.+C1)
      XK5=C2*ARCOS(1.,BXM)
```

```
      XKBW=XK1*(XK2+XK3-XK4-XK5)
   14 XKBW=XKBW/FACT1
      XKBWA=XKBW
   50 CONTINUE
      IF(RB.LE.0.) GO TO 27
      IF(RB.GE.1.) GO TO 28
      PI=3.14159
      T=1./RB
      C1=T+1.
      C2=T**2+1.
      C3=(T+1.)**2
      C4=T-1.
      C5=C4**2
      C6=T**2-1.
      XKWB1=1./PI**2*(PI**2/4.*C3/T**2+PI*C2**2/T**2/C5*ARSIN(C6,C2)-2.*
     1PI*C1/T/C4+C2**2/T**2/C5*(ARSIN(C6,C2))**2-4.*C1/T/C4*ARSIN(C6,C2)
     2+8.*ALOG(C2/(2.*T))/C5)
      GO TO 70
   27 XKWB1=1.
      XKBW1=0.
      XKWB2=1.
      XKBW2=0.
      XKWB12=1.
      XKBW12=0.
      GO TO 660
   28 XKWB1=1.
      XKBW1=1.
      XKWB2=0.
      XKBW2=0.
      XKWB12=0.
      XKBW12=0.
      GO TO 660
   70 CONTINUE
      XKWB2=1.+(XKWB-1.)*F
      XKWB12=1.+(XKWB1-1.)*F
      XKBW12=(XKWB-XKWB1)*F
      IF(VOVS.GT.1..AND.FACTOR.GT.4.) GO TO 750
      IF(LOP.EQ.1) A2=0.
      IF(A2.GT.A1) A2=A1
      XKBW2=XKBWNA+A2/A1*(XKBWA-XKBWNA)
      XKBW2=XKBW2*F
      GO TO 660
  750 CONTINUE
      IF(LOP.EQ.1) A2=0.
      IF(A2.GT.A1) A2=A1
      XKBW2=XKBWNA+A2/A1*(XKBWA-XKBWNA)
      XKBW2=XKBW2*F
      IF(LOP-1) 650,650,660
  650 A1=CR
      A2=CR-CRN
      A3=A2/A1
      XKWB2=(XKWB2-1.)*A3+1.
      XKBW2=XKBW2*A3
      XKWB12=(XKWB12-1.)*A3+1.
      XKBW12=XKBW12*A3
```

```
  660 CONTINUE
      XKWB=XKWB2
      XKBW=XKBW2
      XKWB1=XKWB12
      XKBW1=XKBW12
      RETURN
      END
```

```
      SUBROUTINE FDS (X,X1,X2,X3,X4,X5,F1,F2,F3,F4,F5,FX)                  0  1
      A1=(X-X4)*(X-X5)*(2.*X-X2-X3)+(X-X2)*(X-X3)*(2.*X-X4-X5)
      A2=(X-X4)*(X-X5)*(2.*X-X1-X3)+(X-X1)*(X-X3)*(2.*X-X4-X5)
      A3=(X-X4)*(X-X5)*(2.*X-X1-X2)+(X-X1)*(X-X2)*(2.*X-X4-X5)           0
      A4=(X-X3)*(X-X5)*(2.*X-X1-X2)+(X-X1)*(X-X2)*(2.*X-X3-X5)
      A5=(X-X3)*(X-X4)*(2.*X-X1-X2)+(X-X1)*(X-X2)*(2.*X-X3-X4)           0
      D1=(X1-X2)*(X1-X3)*(X1-X4)*(X1-X5)                                  0  7
      D2=(X2-X1)*(X2-X3)*(X2-X4)*(X2-X5)                                  0  8
      D3=(X3-X1)*(X3-X2)*(X3-X4)*(X3-X5)                                  0  9
      D4=(X4-X1)*(X4-X2)*(X4-X3)*(X4-X5)                                  0 10
      D5=(X5-X1)*(X5-X2)*(X5-X3)*(X5-X4)                                  0 11
      C1=A1/D1                                                            0 12
      C2=A2/D2                                                            0 13
      C3=A3/D3                                                            0 14
      C4=A4/D4                                                            0 15
      C5=A5/D5                                                            0 16
      FX=C1*F1+C2*F2+C3*F3+C4*F4+C5*F5                                    0 17
      RETURN                                                              0 18
      END                                                                 0 19-
```

```
      SUBROUTINE FDP5(TX,TY,X    ,Y,N,J)
      DIMENSION TX(30),TY(30)
      I=0
    1 I=I+1
      IF(TX(I).LE.X    ) GO TO 1
      K=J+2
      IF(I.LE.K) I=K
      IF(I.GT.(N-2)) I=N-2
      CALL FD5(X    ,TX(I-2),TX(I-1),TX(I),TX(I+1),TX(I+2),TY(I-2),TY(I-
     1),TY(I),TY(I+1),TY(I+2),Y    )
      RETURN
      END
```

```
      SUBROUTINE FCINT(TBFR,TK2K1,BFR,TAPAMF,JA)
      DIMENSION TBFR(10),TK2K1(10)
      DO 10 I=1,JA
      IF(BFR-TBFR(I)) 1,10,10
   10 CONTINUE
    1 A=TBFR(I)-TBFR(I-1)
      B=BFR-TBFR(I-1)
      C=TK2K1(I)-TK2K1(I-1)
      X=B*C/A
      TAPAMF=TK2K1(I-1)+X
      RETURN
      END
```

```
      SUBROUTINE GCALC
      DIMENSION V(30,10),AK(10),AS(10),PA(10)
      COMMON/AERO1/GN(10,10),PS(10)
      COMMON/AERO8/NB,NA,MYES,X,IWING
      DO 110 NP=1,NB
      NB1=NB
      NB2=2*NB+1
      NB3=NB+NP
      NB4=2*NB+2*NP+1
      NB5=NB-NP
      NB6=NP
      AK1=1.0
      DO 51 I=2,NB1
      AI=I
   51 AK1=AK1*AI
      AK2=1.0
      DO 61 I=2,NB2
      AI=I
   61 AK2=AK2*AI
      AK3=1.0
      DO 71 I=2,NB3
      AI=I
   71 AK3=AK3*AI
      AK4=1.0
      DO 81 I=2,NB4
      AI=I
   81 AK4=AK4*AI
      AK5=1.0
      IF(NB5-1)83,83,82
   82 DO 91 I=1,NB5
      AI=I
   91 AK5=AK5*AI
   83 CONTINUE
      AK6=1.0
      IF(NB6-1)93,93,92
   92 DO 101 I=1,NB6
      AI=I
  101 AK6=AK6*AI
   93 CONTINUE
      S3=(AK1/AK6)**2
      X4=AK4/(AK2*AK3*AK5)
      S1=(-1.)**NP/2.**(2*NP)
      S2=S3*X4
  110 AK(NP)=S1*S2
      DO 111 I=1,NB
      KDUM1=NB+2-I
      KDUM2=NB+1-I
  111 AS(KDUM1)=AK(KDUM2)
      AS(1)=1.
      KNB=NB+1
      KNB=NB+1
      DO 48 I=1,KNB
      KDUM=NB+2-I
   48 AK(KDUM)=AS(I)
      V(1,1)=0.005
```

```
      V(1,NB)=1.0
      KNB=NB-1
      IF(NB-2)45,45,46
   46 CONTINUE
      ANB=KNB
      DO 66 K=2,KNB
      AI=K-1
   66 V(1,K)=AI/ANB-0.05
   45 CONTINUE
      NBGO=NB-6
      IF(NB  -6)76,76,77
   77 GO TO (73,74,75),NBGO
   73 V(1,6)=V(1,6)+0.06
      GO TO 76
   74 V(1,6)=V(1,6)+0.07
      V(1,7)=V(1,7)+0.07
      GO TO 76
   75 V(1,6)=V(1,6)+0.08
      V(1,7)=V(1,7)+0.08
      V(1,8)=V(1,8)+0.08
   76 CONTINUE
      ANB=NB
      DO 85 K=1,NB
      I=0
   68 I=I+1
      XXD=0.0
      XXF=0.0
      DO 69 J=1,NB
      AJ=J
      XXD=XXD+AK(J)*(ANB-AJ+1.)*V(I,K)**(NB-J)
   69 CONTINUE
      NBB=NB+1
      DO 70 J=1,NBB
      XXF=XXF+AK(J)*V(I,K)**(NB-J+1)
   70 CONTINUE
      V(I+1,K)=V(I,K)-XXF/XXD
      ASTOP=0.000001
      IF(ABS(V(I+1,K)-V(I,K))-ASTOP)86,86,68
   86 PS(K)=V(I+1,K)
      REF=AK(1)
      DO 11 I=1,NB
      DA(I)=0.
      DO 11 J=1,NB
      AJ=J
   11 DA(I)=DA(I)+AK(J)*PS(I)**(NB-J)*(ANB+1.-AJ)/REF
      DO 12 I=1,NB
   12 DA(I)=SQRT (1.    /(1.-PS(I)))/DA(I)
      DO 15 I=1,NB
      GN(1,I)=1.0
      DO 15 J=2,NB
   15 GN(J,I)=AK(J)/REF+PS(I)*GN(J-1,I)
      DO 30 I=1,NB
      DO 30 J=1,NB
   30 GN(J,I)=GN(J,I)*DA(I)
      RETURN
```

```
      END
```

```
      SUBROUTINE GEOM
      COMMON/GEOM/PP(6),X(30),R(30),C2,N,NSHAPE,N1,N2,XB(225),YB(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NBLUNT,N,NNI,IPRINT,NN1A
      COMMON/GEO3/VCVS,AL,XM,YM,XINT,YINT,ANTA
      COMMON/GEO4/K,F,RR,RREF
      COMMON/GEO5/ C3
      COMMON/ICOU/ ICOUNT
      COMMON/LENG/BL,ANL,ALA
      COMMON/VOL/ VOL,CAF,CNF,CMF,RN,DIA,XP,AP,VOLN,CP,CT,BW,CAFWI
      IF(ICOUNT.GT.1) GO TO 31
      READ(5,1) N,NSHAPE,N1,N2,N3,NBLUNT,NFL,NN1A,C2,C4,F,RR
    1 FORMAT(8I5,4F10.5)
   31 C3=C2/C4
C  N= TOTAL NUMBER OF POINTS READ IN ALONG BODY.
C   NSHAPE IS A PARAMETER WHICH DESCRIBES THE BODY SHAPE.
C   NN1=NUMBER OF GRID POINTS COMPUTED ALONG FIRST OGIVE?NN2 ALONG 2ND
C      PORTION OF BODY? NN3 ALONG THIRD PORTION AND NN4 ALONG 4TH SEGMENT.
C     MAXUMUM OF 4 SEGMENTS ALLOWABLE.
C     N3=1 FOR CONICAL BOATTAIL,=2 FOR OGIVAL BOATTAIL. IF OGIVAL BOATTAIL
C        IS PRESENT THEN AT LEAST 5 POINTS MUST BE GIVEN ALONG BOATTAIL.
C   C2 IS A FACTOR WHICH DETERMINES STEP SIZE IN X DIRECTION.
C
C                   POINTED BODY
C
C  NBLUNT=1
C    C2=0.9 AND C4= 20. ARE NOMINAL VALUES FOR THESE PARAMETERS.
C    NSHAPE=1? NOSE ONLY.
C    NSHAPE=2? NOSE PLUS AFTERBODY.
C    NSHAPE=3? NOSE WITH A DISCONTINUITY IN IT. THERE MAY OR MAY NOT BE
C        AN AFTERBODY PRESENT.
C    NSHAPE =4? NOSE PLUS AFTERBODY PLUS BOATAIL.
C    NSHAPE 5? NOSE WITH DISCONTINUITY IN IT PLUS AFTERBODY PLUS BOATAIL.
C    N1=NUMBER OF POINTS ALONG FIRST OGIVE?N2 = NUMBER OF POINTS THROUGH
C       SECOND OGIVE INCLUDING FIRST OGIVE.
C     IF NSHAPE = 3 OR 5 , AT LEAST FIVE POINTS MUST BE READ IN ALONG
C    EACH OF THE OGIVES, EVEN IF THE OGIVE IS A STRAIGHT LINE.
C
C                  BLUNTED BODY
C
C    NBLUNT=2
C   C2=.05 AND C4= 1.0 ARE NOMINAL VALUES FOR THESE PARAMETERS.
C   NFL=1 FOR SPHERICAL CAP? NFL=2 FOR TRUNCATED NOSE.
C    WHEN THE BODY IS BLUNTED NSHAPE MUST BE EITHER 3 OR 5.
C    NSHAPE = 3 NN1A=1? BLUNTED NOSE WITH NO DISCONTINUITIES OTHER THAN THE
C      INTERSECTION OF THE CAP WITH OGIVE.
C    NSHAPE=3, NN1A=2? BLUNTED NOSE WITH A DISCONTINUITY IN THE OGIVE SO THERE
C      ARE 2 OGIVES PRESENT.
C    NSHAPE=5,NN1A=1? SAME AS ABOVE EXCEPT BOATTAIL PRESENT.
C    NSHAPE=5,NN1A =2? SAME AS ABOVE EXCEPT BOATTAIL PRESENT.
C    IF NN1A =1 , THEN N1=1 AND N2.GE.5? IF NN1A=2, THEN N1.GE.5 AND N2. GE.9
C  RR = RADIUS OF SPHERICAL CAP IN CALIBERS(OR TRUNCATED PORTION).
      TJ=1
      IF(ICOUNT.GT.1) GO TO 32
      WRITE(6,34)
```

```
34    FORMAT(//,53X,*BODY COORDINATES *,//,55X,*X*,11X,*R*,/)
      DO 2 I=1,N
      READ(5,3) X(I),R(I)
      WRITE(6,33) X(I),R(I)
33    FORMAT(47X,2F12.4)
2     CONTINUE
3     FORMAT(2F15.10)
32    IF(NBLUNT.EQ.2) CALL BLUNT
      IF(NBLUNT.EQ.2) GO TO 5
      XB(1)=X(1)
      RB(1)=R(1)
      IF(N1.NE.2) GO TO 4
      IF(NN1A.EQ.2) GO TO 4
510   DO 508 I=2,5
      RP(I)=(R(I)-R(1))/(X(I)-X(1))
      TA=RP(I)
      TABE=BETA*TA
      IF(TABE.LT.0.94) GO TO 509
508   CONTINUE
509   XB(2)=X(I)
      RB(2)=R(I)
      RP(1)=RP(I)
      NN1=2
      K=1
      RBP(1)=RP(1)
      RBP(2)=RBP(1)
      GO TO 5
4     DO 6 J=1,5
      L=1
      CALL FDP5(X,R,X(J),RP(J),N2,L)
6     CONTINUE
      TA=RP(1)
      TABE=BETA*TA
      RBP(1)=TA
      IF(N1.EQ.2) GO TO 510
      IF(TABE.LT..94) GO TO 503
      DO 505 I=1,5
      TABE=BETA*RP(I)
      IF(TABE.LE.0.94) GO TO 506
505   CONTINUE
506   XB(2)=X(I)
      RB(2)=R(I)
      RBP(2)=RP(I)
      RP(1)=RP(I)
      RP(1)=0.
      RBP(1)=RP(1)
      XB(1)=XB(2)-RB(2)/RP(1)
      XB(3)=XB(2)+0.01
      JJ=3
      JK=2
      JU=N1
      GO TO 507
503   CALL FD5(X(1),X(1),X(2),X(3),X(4),X(5),RP(1),RP(2),RP(3),RP(4),
     1RP(5),RPP)
      RHOB=ABS((1.+RP(1)**2)**1.5/RPP)
```

```
      XB(2)=0.025*RHOB/BETA**1.5    +XB(1)
      IF(XB(2).GT.(X(N1)/5.)) XB(2)=X(N1)/5.
      JJ=2
      JK=1
      JU=N1
      IF(NN1A.EQ.2) JU=N2
  507 J=1
      DO 7 K=JJ,50
      CALL INTERP(X,R,XB(K),RB(K),JU,3)
      CALL FDP5(X,R,XB(K),RBP(K),JU,J)
      BET1=BETA
      IF(BET1.GT.1.) BET1=1.
      XB(K+1)=XB(K)+BET1*(RB(K)-RB(JK))*C2
      IF(XB(K+1).GE.X(N1)) GO TO 8
    7 CONTINUE
    8 XB(K+1)=X(N1)
      RB(K+1)=R(N1)
      NN1=K+1
      NN2=NN1+10
      CALL FDP5(X,R,XB(K+1),RBP(K+1),JU,J)
    5 GO TO(9,10,11,12,11) ,NSHAPE
    9 NN=NN1
      ANL=XB(NN)
      BL=0.
      ALA=0.
      GO TO 99
   10 XB(K+2)=X(N1)
      RB(K+2)=R(N1)
      RBP(K+2)=0.
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+3)=C3    *BET1*RB(K+2)+XB(K+2)
      RB(K+3)=RB(K+2)
      RBP(K+3)=0.
   14 K=K+1
      IJ=IJ+1
      A=IJ
      C5=A*C3
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+3)=C5*BET1*RB(K+2)+XB(K+2)
      RB(K+3)=RB(K+2)
      RBP(K+3)=0.
      IF(XB(K+3).LT.X(N)) GO TO 14
      XB(K+3)=X(N)
      RB(K+3)=R(N)
      NN=K+3
      NN2=K+3
      ANL=XB(NN1)
      BL=0.
      ALA=XB(NN)-XB(NN1)
      NN3=NN2+10
      GO TO 99
   11 XB(K+2)=X(N1)
      RB(K+2)=R(N1)
```

```
      J=N1
      CALL FDP5(X,R,XB(K+2),RBP(K+2),N2,J)
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+3)=XB(K+2)+C3   *BET1*RB(K+2)
      CALL INTERP(X,R,XB(K+3),RB(K+3),N2,3)
      CALL FDP5(X,R,XB(K+3),RBP(K+3),N2,J)
   15 K=K+1
      IJ=IJ+1
      A=IJ
      C5=A*C3
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+3)=XB(K+2)+C5*BET1*RB(K+2)
      IF(XB(K+3).GE.X(N2)) XB(K+3)=X(N2)
      CALL INTERP(X,R,XB(K+3),RB(K+3),N2,3)
      CALL FDP5(X,R,XB(K+3),RBP(K+3),N2,J)
      IF(XB(K+3).LT.(X(N2)-.0001)) GO TO 15
      IJ=1
      XB(K+3)=X(N2)
      RB(K+3)=R(N2)
      NN2=K+3
      ANL=XB(NN2)+RR
      IF(NFL.EQ.2) ANL=XB(NN2)
      BL=0.
      ALA=0.
      CALL FDP5(X,R,XB(K+3),RBP(K+3),N2,J)
      IF(XB(K+3).LT.(X(N)-.0001)) GO TO 30
      NN=K+3
      NN3=K+3
      GO TO 99
   30 RBP(K+4)=0.
      XB(K+4)=XB(K+3)
      RB(K+4)=RB(K+3)
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+5)=C3/10.*BET1*RB(K+4)+XB(K+4)
      RB(K+5)=RB(K+4)
      RBP(K+5)=0.
   16 K=K+1
      IJ=IJ+1
      A=IJ
      C5=A*C3
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      CZE=BETA**3
      IF(CZE.GT.10.) CZE=10.
      XB(K+5)=C5*BET1*RB(K+4)/CZE+XB(K+4)
      RB(K+5)=RB(K+4)
      RBP(K+5)=0.
      IF(XB(K+5).LT.X(N2+1)) GO TO 16
      XB(K+5)=X(N2+1)
      RB(K+5)=R(N2+1)
      NN3=K+5
      ALA=XB(NN3)-XB(NN2)
```

```
      IF(NSHAPE.EQ.5) GO TO 13
       N=K+5
      GO TO 99
   12 XB(K+2)=X(N1)
      RB(K+2)=R(N1)
      RBP(K+2)=0.
      ANL=XB(NN1)
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+3)=C3/10.*BET1*RB(K+2)+XB(K+2)
      RB(K+3)=RB(K+2)
      RBP(K+3)=0.
   17 K=K+1
      IJ=IJ+1
      A=IJ
      C5=A*C3
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+3)=XB(K+2)+C5*BET1*RB(K+2)/BETA**3
      RB(K+3)=RB(K+2)
      RBP(K+3)=0.
      IF(XB(K+3).LT.X(N1+1)) GO TO 17
      XB(K+3)=X(N1+1)
      RB(K+3)=R(N1+1)
      NN2=K+3
      ALA=XB(NN2)-XB(NN1)
      IJ=1
      XB(K+4)=XB(K+3)
      RB(K+4)=RB(K+3)
      RBP(K+4)=RBP(K+3)
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+5)=XB(K+4)+C3    *BET1*RB(K+4)
      IF(N3.EQ.2) GO TO 20
      IF(ICOUNT.GT.1) GO TO 517
      SLOPE=(R(N)-RB(K+4))/(X(N)-XB(K+4)) +1./57.293
      IF(SLOPE.LT.-0.0872) SLOPE=-.0872
      R(N)=SLOPE*(X(N)-XB(K+4))+RB(K+4)
  517 RB(K+5)=RB(K+4)+SLOPE*(XB(K+5)-XB(NN2))
      RBP(K+4)=SLOPE
      RBP(K+5)=SLOPE
      GO TO 21
   20 CALL INTER5(XB(K+5),X(N-4),X(N-3),X(N-2),X(N-1),X(N),R(N-4),
     1R(N-3),R(N-2),R(N-1),R(N),RB(K+5))
      CALL FD5(XB(K+5),X(N-4),X(N-3),X(N-2),X(N-1),X(N),R(N-4),R(N-3),
     1R(N-2),R(N-1),R(N),RBP(K+5))
   21 IF(XB(K+5).LT.X(N)) GO TO 18
      XB(K+5)=X(N)
      RB(K+5)=R(N)
      NN3=K+5
      BL=XB(NN3)-XB(NN2)
      NN=K+5
      GO TO 99
   18 K=K+1
      IJ=IJ+1
```

```
      A=IJ
      C5=A*C3
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+5)=XB(K+4)+C5*BET1*RB(K+4)
      IF(N3.EQ.2) GO TO 22
      RB(K+5)=RB(NN2)+SLOPE*(XB(K+5)-XB(NN2))
      RBP(K+5)=SLOPE
      GO TO 23
   22 CALL INTERP5(XB(K+5),X(N-4),X(N-3),X(N-2),X(N-1),X(N),R(N-4),
     1R(N-3),R(N-2),R(N-1),R(N),RB(K+5))
      CALL FD5(XB(K+5),X(N-4),X(N-3),X(N-2),X(N-1),X(N),R(N-4),R(N-3),
     1R(N-2),R(N-1),R(N),RBP(K+5))
   23 IF(XB(K+5).LT.X(N)) GO TO 18
      XB(K+5)=X(N)
      RB(K+5)=R(N)
      NN3=K+5
      NN=K+5
      BL=XB(NN3)-XB(NN2)
      GO TO 99
   13 XB(K+6)=XB(K+5)
      RB(K+6)=RB(K+5)
      IJ=1
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+7)=XB(K+6)+C3/2.*BET1*RB(K+6)
      IF(N3.EQ.2) GO TO 24
      IF(ICOUNT.GT.1) GO TO 516
      SLOPE=(R(N)-RB(K+6))/(X(N)-XB(K+6)) +1./57.293
      IF(SLOPE.LT.-0.0872) SLOPE=-.0872
      R(N)=SLOPE*(X(N)-XB(K+6))+RB(K+6)
  516 RB(K+7)=RB(K+6)+SLOPE*(XB(K+7)-XB(NN3))
      RBP(K+6)=SLOPE
      RBP(K+7)=SLOPE
      GO TO 25
   24 CALL INTERP5(XB(K+7),X(N-4),X(N-3),X(N-2),X(N-1),X(N),R(N-4),
     1R(N-3),R(N-2),R(N-1),R(N),RB(K+7))
      CALL FD5(XB(K+7),X(N-4),X(N-3),X(N-2),X(N-1),X(N),R(N-4),R(N-3),
     1R(N-2),R(N-1),R(N),RBP(K+7))
   25 IF(XB(K+7).LT.X(N)) GO TO 19
      XB(K+7)=X(N)
      RB(K+7)=R(N)
      NN4=K+7
      NN=K+7
      BL=XB(NN4)-XB(NN3)
      GO TO 99
   19 K=K+1
      IJ=IJ+1
      A=IJ
      C5=A*C3
      BET1=BETA
      IF(BET1.GT.1.0) BET1=1.
      XB(K+7)=XB(K+6)+C5*BET1*RB(K+6)
      IF(N3.EQ.2) GO TO 26
      RB(K+7)=RB(NN2)+SLOPE*(XB(K+7)-XB(NN3))
```

```
      PPP(K+7)=SLOPE
      GO TO 27
   26 CALL INTER5(XB(K+7),X(N-4),X(N-3),X(N-2),X(N-1),X(N),P(N-4),
     1P(N-3),P(N-2),P(N-1),P(N),PB(K+7))
      CALL FD5(XB(K+7),X(N-4),X(N-3),X(N-2),X(N-1),X(N),P(N-4),P(N-3),
     1P(N-2),P(N-1),P(N),PPP(K+7))
   27 IF(XB(K+7).LT.X(N)) GO TO 19
      XB(K+7)=X(N)
      PB(K+7)=P(N)
      NN=K+7
      NP4=K+7
      BL=XB(NN)-XB(NN3)
   99 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE GEOM1
      COMMON/AERO4/RS1(10),RS2(20),S(20)
      COMMON/AERO7/XLEDGE(20),XTEDGE(20),C([illegible])
      COMMON/AERO9/N1,N2,N4
      COMMON/AERO10/SPAN,CR,CT,OMEGA,RSS
      S1=SPAN*RSS/2.
      S2=SPAN/2.
      LA=N1+1
      LB=N1+N2
      OMEGA=OMEGA/57.3
      CO=CR-2.*S1*(CR-CT)/SPAN
      TO=TAN(OMEGA)
      DO 3 I=1,N1
      C(I)=CR-(CR-CO)*RS1(I)
      XLEDGE(I)=S1*RS1(I)*TO
    3 XTEDGE(I)=C(I)+XLEDGE(I)
      DO 21 I=LA,LB
      C(I)=CR+(CR-CT)*RS2(I)
      XLEDGE(I)=-S2*RS2(I)*TO
      XTEDGE(I)=C(I)+XLEDGE(I)
   21 CONTINUE
      DO 11 I=LA,LB
   11 S(I)=S2
      DO 13 I=1,N1
   13 S(I)=S1
      RETURN
      END
```

```
      SUBROUTINE GUIDED(AP,BVEC,NSQ,CNAF,[illegible],XCREF)
      COMMON/Z/XLE(4),XTE(4),Y(4),GAMA,X[illegible]
      REAL MACH
      DIMENSION AP(NSQ,NSQ),BVEC(NSQ,1)
      DIMENSION ALCH(20),DECUT(10),DEIN(10),XA(10),X1(10,10),X2(10,10),
     *          HD1(10,10),PL1(10),RD1(10)
      COMMON/AERO1/GN(10,10),PS(10)
      COMMON/AERO2/PL(10),RD(10),R(10,10),HD(10,10)
      COMMON/AERO3/H1(10,10),HH1(10)
      COMMON/AERO4/PS1(10),PS2(20),S(20)
      COMMON/AERO5/GN1(10,10),GN2(10,10)
      COMMON/AERO6/DI12(20,20),DI21(20,20),PI11(10,10),PI22(10,10)
      COMMON/AERO7/XLEDGE(20),XTEDGE(20),C(20)
      COMMON/AERO8/NB,NA,MYES,X,IWING
      COMMON/AERO9/N1,N2,N4
      COMMON/AERO10/SPAN,CR,CT,OMEGA,PSS
      COMMON/AERO11/SAREA,ALPHAWB,CLT,BETAM
      COMMON/ANAME/ROLL,PITCH,MACH,ALPHA,RC,XCG,DIHED
      PI=3.1415927
      CRM=CR
      THETA=0.
      DX1=0.00999
      DX2=0.09999
      XCRIT=0.2
      ADX=4.0
      ALPHAWB=ALPHA
      ALS=ALPHA*.01745329
      DH=COS(DIHED/57.3)
      BETAM=SQRT(1.-MACH**2)
      CR=CR/BETAM
      CT=CT/BETAM
      RC=RC/BETAM
      OMEGA=OMEGA/57.3
      GAMA=OMEGA
      OMEGA=ATAN(TAN(OMEGA)/BETAM)*57.3
      ALPHA=ALPHA*DH
      MYES=0
      LA=N1+1
      LB=N1+N2
      NB=N1
      CALL GCALC
      DO 35 I=1,N1
      KDUM=NB-I+1
      DO 35 J=1,NB
      GN1(I,J)=GN(KDUM,J)
   35 PS1(I)=PS(I)
      NB=N2
      CALL GCALC
      DO 36 I=1,NB
      KDUM=NB-I+1
      KD=I+N1
      PS2(KD)=-PS(I)
      PS2(I)=-PS1(I)
      DO 36 J=1,NB
   36 GN2(I,J)=GN(KDUM,J)
```

```
      CALL GEOM1
      DO 5000 III=1,4
      XLF(III)=XLEDGE(III)
      XTE(III)=XTEDGE(III)
      Y(III)=RS1(III)
 5000 CONTINUE
      NA=N4
      CALL HCALC
      DO 30 I=1,NA
      RL1(I)=RL(I)
      RD1(I)=RD(I)
      KDUM=NA-I+1
      DO 30 J=1,NA
      HD1(I,J)=HD(J,I)
   30 H1(I,J)=B(KDUM,J)
      NA=N4
      IWING=1
      X=RD1(1)
      CALL HINT
      CALL PQRINT(DX1)
      CALL STNG (ALGW,C)
      DO 5926 I=1,NSQ
      DO 5926 J=1,NSQ
 5926 AP(I,J)=0.0
      DO 5927 I=1,NSQ
      AP(I,I)=1.0
 5927 BVEC(I,1)=1.0
      DEOUT(1)=1.0
      L=0
      IST=1
      ISCD=N1
 1096 DO 1000 JR=IST,ISCD
      DO 1000 K=1,N4
      L=L+1
      KC=0
      DO 140 J=1,N1
      IWING=1
      NA=N4
      IF(J-JR)80,60,80
   60 X=RD1(K)
      CALL HINT
      DO 70 I=1,NA
      KC=KC+1
      RX=-ALGW(JR)*HD1(K,I)
      BW=1./(2.*PI*S(J))*C(J)*S(J)**2
      XA(I)=WH1(I)*BW
   70 AP(L,KC)=XA(I)*PI11(J,JR)+RX
      GO TO 140
   80 NGRAT=NA+1
      B2=S(JR)*RS1(JR)-S(J)*RS1(J)                              Y-YO
      IF(IST-1)1061,1061,1062
 1062 B2=S(JR)*RS2(JR)-S(J)*RS1(J)
 1061 CONTINUE
      B3=S(J)*C(J)*B2**2/(4.*PI)
      DX=DX2
```

```
      IF(ABS(B2)-XCPIT/1.*C(J)) 2300,2300,2400
 2300 DX=DX2/ADX*2.
 2400 CONTINUE
      DO 90 I=1,NGRAT
   90 DEIN(I)=0.0
      DEIN(1)=0.000001
  100 CONTINUE
      DO 120 M1=1,4
      X=DEIN(1)
      CALL HINT
      DO 110 I=2,NGRAT
      B1=C(JR)*RD1(K)-C(J)*X+XLEDGE(JR)-XLEDGE(J)                X-X0
      BY=B3*C(J)/(B1**2+B2**2)**1.5
  110 DEOUT(I)=HH1(I-1)*BY
      CALL RK(DEOUT,DEIN,DX,NGRAT,M1)
  120 CONTINUE
      IF(DEIN(1)-0.99)100,100,130
  130 B4=(1.+B1/SQRT(B1**2+B2**2))/B2**2
      DO 104 I=2,NGRAT
      XA(I)=DEIN(I)
      KC=KC+1
      XDUM=PI11(J,JR)
      IF(IST-1)1031,1031,1032
 1032 XDUM=QI12(J,JR)
 1031 CONTINUE
      B7=HH1(I-1)*B4*B3
      AP(L,KC)=(XA(I)+B7)*XDUM
  104 CONTINUE
  140 CONTINUE
      DO 141 J=LA,LB
      K1=J-N1
      K2=JR-N1
      IWING=1
      NA=N4
      IF(J-JR)81,61,81
   61 X=RD1(K)
      CALL HINT
      DO 71 I=1,NA
      KC=KC+1
      BW=1./(2.*PI*S(J))*C(J)*S(J)**2
      BX=-ALGW(JR)*HD1(K,I)
      XA(I)=HH1(I)*BW
   71 AP(L,KC)=XA(I)*PI22(K1,K2)+BX
      GO TO 141
   81 NGRAT=NA+1
      B2=S(JR)*PS1(JR)-S(J)*PS2(J)                               Y-Y0
      IF(IST-1)1064,1064,1065
 1065 B2=S(JR)*PS2(JR)-S(J)*PS2(J)
 1064 CONTINUE
      B3=S(J)*C(J)*B2**2/(4.*PI)
      DX=DX2
      IF(ABS(B2)-XCPIT/1.*C(J)) 2301,2301,2401
 2301 DX=DX2/ADX*2.
 2401 CONTINUE
      DO 91 I=1,NGRAT
```

```
  91    DFIN(I)=0.0
        DFIN(1)=0.000001
 101    CONTINUE
        DO 121 M1=1,4
        X=DFIN(1)
        CALL HINT
        DO 111 I=2,NGRAT
        B1=C(JR)*RD1(K)-C(J)*X+XLEDGE(JR)-XLEDGE(J)                X-XO
        BY=B3*C(J)/(B1**2+B2**2)**1.5
 111    DEOUT(I)=HH1(I-1)*BY
        CALL RK(DEOUT,DFIN,DX,NGRAT,M1)
 121    CONTINUE
        IF(DFIN(1)-0.99)101,101,131
 131    B4=(1.+B1/SQRT(B1**2+B2**2))/B2**2
        DO 114 I=2,NGRAT
        XA(I)=DFIN(I)
        KC=KC+1
        XDUM=QI21(J,JR)
        IF(IST-1)1041,1041,1042
1042    XDUM=PI22(K1,K2)
1041    CONTINUE
        BZ=HH1(I-1)*B4*B3
        AP(L,KC)=(XA(I)+BZ)*XDUM
 114    CONTINUE
 141    CONTINUE
 142    CONTINUE
1000    CONTINUE
        IST=IST+N1
        ISCD=LB
        DO 5281 I4=13,24
        DO 5280 J4=1,24
        K4=J4
        IF(J4.GT.12) K4=J4-24
        K4=K4+12
        AP(I4,J4)=AP(I4-12,K4)
5280    CONTINUE
5281    CONTINUE
1097    CONTINUE
 539    ALPH=ALPHA
        VO=MACH*1100.
        IF(MACH.EQ.0.) VO=1.
        S2=SPAN/2.
        S1=S2*PSS
        IK=0
        DO 210 I=1,LB
        DO 210 K=1,N4
        IK=IK+1
 210    BVEC(IK,1)=(-XCG+XLEDGE(I)+RD1(K)*C(I))*PITCH*DH/VO+ALPH/57.3
        IK=0
        DO 3 I=1,N1
        DO 3 K=1,N4
        IK=IK+1
   3    BVEC(IK,1)=BVEC(IK,1)-PS1(I)*S1*ROLL/VO
        DO 4 I=1,N2
        DO 4 K=1,N4
```

```
      IK=IK+1
    4 BVEC(IK,1)=BVEC(IK,1)-PS2(I)*S2*ROLL/VO
      CALL MINVR (AP,NSO,BVEC,1,DETERM,IERR)
      L=0
      DO 798 J=1,N1
      DO 899 I=1,N4
      L=L+1
  899 X1(I,J)=BVEC(L,1)*2.
  798 CONTINUE
      DO 802 J=1,N2
      DO 900 I=1,N4
      L=L+1
  900 X2(I,J)=BVEC(L,1)*2.
  802 CONTINUE
      CALL DIST (X1,X2,S)
      CNAF=-CLT/AL5
      XCPFF=XCPF+XLEF
      RETURN
      END
```

```
      SUBROUTINE HCALC
      DIMENSION A(10,10),DA(10)
      COMMON/AERO2/RL(10),RD(10),B(10,10),HD(10,10)
      COMMON/AERO8/NB,NA,MYES,X,IWING
      ANA=NA
      DO 10 I=1,NA
      AI=I
      RL(I)=0.5*(1.-COS ((2.*AI-1.)/(2.*ANA+1.)*3.14159271)
      KDUM=NA+1-I
   10 RD(KDUM)=1.-RL(I)
      A(1,1)=1.
      DO 1  I=2,NA
      A(I+1,I-1)=0.0
    1 A(1,I)=1.
      A(2,1)=-RL(1)
      I1=3
      J1=2
    2 J=J1
      DO 3 I=2,I1
    3 A(I,J)=-A(I-1,J-1)*RL(J)+A(I,J-1)
      I1=I1+1
      J1=J1+1
      IF(J1-NA)2,2,4
    4 CONTINUE
      DO 11 I=1,NA
      DA(I)=0.
      DO 11 J=1,NA
      AJ=J
   11 DA(I)=DA(I)+A(J,NA)*RL(I)**(NA-J)*(ANA+1.-AJ)
      DO 12 I=1,NA
   12 DA(I)=SQRT (RL(I)/(1.-RL(I)))/DA(I)
      DO 15 I=1,NA
      B(1,I)=1.
      DO 15 J=2,NA
   15 B(J,I)=A(J,NA)+RL(I)*B(J-1,I)
      DO 30 I=1,NA
      DO 30 J=1,NA
   30 B(J,I)=B(J,I)*DA(I)
      DO 902 K=1,NA
      NAB=NA-1
      ANA=NAB
      DO 902 I=1,NA
      XXF=0.
      XXD=0.
      DO 900 J=1,NAB
      AJ=J
  900 XXD=XXD+B(J,I)*RD(K)**(NAB-J)*(ANA-AJ+1.)
      DO 901 J=1,NA
  901 XXF=XXF+B(J,I)*RD(K)**(NAB-J+1)
      XF1=SQRT((1.-RD(K))/RD(K))
      XF2=1./RD(K)+1./(1.-RD(K))
  902 HD(I,K)=(XXD-XXF/2.*XF2)*XF1
      RETURN
      END
```

```
      SUBROUTINE HINT
      DIMENSION Q(10,10),AAI(10),AA(10),HH2(10)
      COMMON/AERO3/H1(10,10),HH1(10)
      COMMON/AERO8/NB,NA,MYES,X,THING
      MYES=MYES+1
      IF(MYES-1)800,800,801
  800 CONTINUE
      Q(1,1)=1.
      DO 930 K=2,9
      AK=K
      Q(1,K)=1./AK
      Q(2,K)=Q(1,K-1)*(2.*AK-3.)/(2.*AK)
      Q(2,K)=Q(2,K)-1./AK
  930 CONTINUE
  960 DO 940 K=3,9
      AK=K
      DO 940 I=3,K
  940 Q(I,K)=Q(I-1,K-1)*(2.*AK-3.)/(2.*AK)
  801 CONTINUE
      ASQ=SQRT (X*(1.-X))
      DO 970 I=1,9
  970 AA(I)=X**I
      AFX=SQRT (X/(1.-X))
      ASI=ATAN (AFX)
      AAI(1)=ASI+ASQ
      DO 982 K=2,NA
      KA=K-1
      AAI(K)=Q(K,K)*(ASQ-ASI)
      DO 982 I=1,KA
      KDUM=KA+1-I
      AAI(K)=AAI(K)+ASQ*Q(I,K)*AA(KDUM)
  982 CONTINUE
      DO 999 K=1,NA
      HH1(K)=0.0
      DO 999 I=1,NA
      KDUM=I
  999 HH1(K)=HH1(K)+AAI(I)*H1(KDUM,K)
      RETURN
      END
```

```
      SUBROUTINE HYBRID
      COMMON/GEOM/RP(6),X(30),R(30),C2,N,NSHAPE,N1,N2,XB(225),RB(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NBLUNT,NN,NNI,IPRINT,NN1A
      COMMON/GEO3/VOVS,AL,XM,YM,YINT,YINT,NNIA
      COMMON/GEO4/K,F,RR,RREF
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,CABLW
      COMMON/DAT1/ T(100),AK(100),AE(100),C(225),C1(225),C3
      COMMON/DISC/ I,JK,AI2,SUM,JH,PI
      COMMON/DIS1/J1,J3
      COMMON/WAVE/CABL,CNBL,CMBL,CAW,CNW,CMW
      COMMON/CPV/ CPV(225,7),JA,JB
      COMMON/VOL/ VOL,CAF,CNF,CMF,RN,DIA,XP,AP,VOLN,CR,CT,BW,CAFWI
      COMMON/DISP/ RB1(225),RBP1(225),B(225)
      DIMENSION PSI(225),PHI(225),ZEOX(225),ZEOR(225),ZEO(225),
     1ZEOXX(225),ZEOXR(225),ZEORR(225),PSIX(225),PSIR(225),ZEOP(225),
     2ZEOPX(225),ZEOPR(225),PHIX(225),PHIR(225),       ZE1(225),
     1ZE1X(225),ZE1R(225)
      DIMENSION THET(20),THET1(20)
      DATA(T(I),I=1,99)/.01,.02,.03,.04,.05,.06,.07,.08,.09,.10,.11,.12,
     1.13,.14,.15,.16,.17,.18,.19,.20,.21,.22,.23,.24,.25,.26,.27,.28,
     2.29,.30,.31,.32,.33,.34,.35,.36,.37,.38,.39,.40,.41,.42,.43,.44,
     3.45,.46,.47,.48,.49,.50,.51,.52,.53,.54,.55,.56,.57,.58,.59,.60,
     4.61,.62,.63,.64,.65,.66,.67,.68,.69,.70,.71,.72,.73,.74,.75,.76,
     5.77,.78,.79,.80,.81,.82,.83,.84,.85,.86,.87,.88,.89,.90,.91,.92,
     6.93,.94,.95,.96,.97,.98,.99/
      DATA(AK(I),I=1,99)/3.35902,3.02571,2.83492,2.70218,2.60107,
     12.51987,2.45234,2.39475,2.34473,2.30064,2.26132,2.22592,2.19380,
     22.16445,2.13748,2.11257,2.08946,2.06794,2.04782,2.02896,2.01123,
     31.99451,1.97871,1.96376,1.94957,1.93608,1.92324,1.91099,1.89929,
     41.88811,1.87740,1.86713,1.85727,1.84780,1.83870,1.82993,1.82148,
     51.81331,1.80547,1.79787,1.79053,1.78343,1.77655,1.76989,1.76344,
     61.75718,1.75111,1.74521,1.73948,1.73392,1.72851,1.72324,1.71812,
     71.71313,1.70827,1.70354,1.69892,1.69442,1.69003,1.68575,1.68157,
     81.67748,1.67350,1.66960,1.66579,1.66206,1.65842,1.65485,1.65137,
     91.64795,1.64461,1.64133,1.63813,1.63499,1.63191,1.62889,1.62593,
     A1.62303,1.62018,1.61739,1.61465,1.61196,1.60932,1.60672,1.60418,
     B1.60168,1.59922,1.59680,1.59443,1.59210,1.58981,1.58755,1.58534,
     C1.58316,1.58101,1.57890,1.57683,1.57479,1.57278/
      DATA(AE(I),I=1,99)/1.02836,1.04970,1.06835,1.08526,1.10085,
     11.11541,1.12909,1.14204,1.15433,1.16606,1.17727,1.18802,1.19835,
     21.20828,1.21786,1.22711,1.23604,1.24469,1.25307,1.26119,1.26907,
     31.27672,1.28416,1.29139,1.29843,1.30528,1.31196,1.31847,1.32482,
     41.33102,         1.33707,1.34298,1.34875,1.35439,1.35991,1.365[illegible],
     51.37059,1.37575,1.38082,1.38577,1.39063,1.39539,1.40005,1.40463,
     61.40911,1.41351,1.41783,1.42207,1.42623,1.43032,1.43433,1.43827,
     71.44214,1.44594,1.44968,1.45336,1.45697,1.46053,1.46402,1.46746,
     81.47085,1.47417,1.47745,1.48068,1.48385,1.48698,1.49006,1.49309,
     91.49607,1.49902,1.50192,1.50477,1.50759,1.51036,1.51310,1.51579,
     A1.51845,1.52107,1.52366,1.52621,1.52872,1.53121,1.53365,1.53607,
     B1.53845,1.54081,1.54313,1.54542,1.54769,1.54992,1.55213,1.5543[illegible],
     C1.55646,1.55858,1.56068,1.56275,1.56480,1.566[illegible]2,1.56882/
      PI=3.1415927
      T(100)=1.
      AK(100)=PI/2.
```

```
      AF(100)=AK(100)
C     THIS SUBROUTINE COMPUTES THE SECOND ORDER AXIAL AND FIRST
C       ORDER CROSS FLOW PERTURBATION VELOCITY COMPONENTS. THESE
C         COMPONENTS ARE THEN COMBINED TO YIELD A HYBRID SOLUTION.
      IKK=1
      IK=1
      THET(1)=0.
      THET1(1)=0.
      DO 47 IJ=2,7
      THET1(IJ)=THET1(IJ-1)+30.
      THET(IJ)=THET1(IJ)/57.29583
   47 CONTINUE
   17 TA=RP(1)
      IF(IPRINT.NE.1) GO TO 118
      WRITE(6,140) VOVS
  140 FORMAT(//,47X,*PRESSURE COEFFICIENTS AT M = *,F6.3,//)
  118 TA2=TA**2
      C(1)=TA2/SQRT(1.-BETA**2*TA2)
C    CONICAL SOLUTION , SUBSCRIPT=1
      F11= ARSECH(BETA*TA)
      F22= SQRT(1.-BETA**2*TA2)
      ZEO(1)=(F22-F11)*C(1)
      ZEOX(1)=-C(1)*F11
      ZEOR(1)=C(1)*F22/TA
      ZEOXX(1)=-1./F22*C(1)
      ZEOXR(1)=1./(F22*TA)*C(1)
      ZEORR(1)=-1./(F22*TA2)*C(1)
C   PARTICULAR SOLUTION AT TIP
      I=1
      AN=1.2*VOVS**2/BETA**2
      PSIX(I)=VOVS**2*((ZEO(I) +AN*TA    *ZEOR(I))*ZEOXX(I) + ZEOX(I)*(
     1ZEOX(I)+AN*TA    *ZEOXR(I))-0.75*TA    *ZEOR(I)**2*ZEOXR(I))
      PSIR(I)=VOVS**2*((ZEO(I)+AN*TA    *ZEOR(I))*ZEOXR(I)+ZEOX(I)*((AN
     1+1.)*ZEOR(I)+AN*TA    *ZEORR(I))-0.25*ZEOR(I)**2*(ZEOR(I)+3.*TA
     2*ZEORR(I)))
C    COMPLIMENTARY SOLUTION AT TIP.
      C1(1)=TA*(TA*(1.+ZEOX(1))-PSIR(1))/F22
      AB=C1(1)/C(1)
      ZEOP(1)=AB*ZEO(1)
      ZEOPX(1)=AB*ZEOX(1)
      ZEOPR(1)=AB*ZEOR(1)
C   TOTAL SOLUTION AT TIP= PARTICULAR PLUS COMPLIMENTARY.
      PHIX(1)=PSIX(1)+ZEOPX(1)
      PHIR(1)=PSIR(1)+ZEOPR(1)
      QB=(1.+ZEOX(I))**2+ZEOR(I)**2
      CP01=2./(1.4*VOVS**2)*((1.+0.2*VOVS**2*(1.-QB))**3.5 - 1.)
      QB=(1.+PHIX(I))**2+PHIR(I)**2
      CPV(1,1)=2./(1.4*VOVS**2)*((1.+0.2*VOVS**2*(1.-QB))**3.5-1.)
      CP02=CPV(1,1)
  119 IF(NN.EQ.2) GO TO 35
C     FIRST ORDER AXIAL FLOW
      DO 7 I=2,NN
      SUM=0.
      IF(I.EQ.2) GO TO 36
      J2=I-1
```

```
      DO 8 J=2,J2
      XI=XB(J-1)-BETA*RB(J-1)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.0) TAU=.999999
      SUM=SUM+BETA*C(J)*(XB(I)-XI)*(SQRT(1.-TAU**2)/TAU-TAU*ARSECH(TAU))
    8 CONTINUE
      JH=NN1+1
      IF(I.LE.JH) GO TO 36
      CALL DISC1
      J=NN1+1
      XI=XB(J-1)-BETA*RB(J-1)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.999999999
      SUM=SUM-BETA*C(J)*(XB(I)-XI)*(SQRT(1.-TAU**2)/TAU-TAU*ARSECH(TAU))
      JH=NN2+1
      IF(I.LE.JH) GO TO 36
      CALL DISC1
      J=NN2+1
      XI=XB(J-1)-BETA*RB(J-1)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.999999999
      SUM=SUM-BETA*C(J)*(XB(I)-XI)*(SQRT(1.-TAU**2)/TAU-TAU*ARSECH(TAU))
      JH=NN3+1
      IF(I.LE.JH) GO TO 36
      CALL DISC1
      J=NN3+1
      XI=XB(J-1)-BETA*RB(J-1)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.999999999
      SUM=SUM-BETA*C(J)*(XB(I)-XI)*(SQRT(1.-TAU**2)/TAU-TAU*ARSECH(TAU))
   36 XI=XB(I-1)-BETA*RB(I-1)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.999999999
      TAU1=BETA*RB(I)/(XB(I)-XB(1)+BETA*RB(1))
      IF(TAU.GE.1.0) TAU=.999999
      TT=C(1)*BETA*SQRT(1.-TAU1**2)/ TAU1
      DEN=BETA*(XB(I)-XI)*(SQRT(1.-TAU**2)/TAU-TAU*ARSECH(TAU))
      C(I)=(RBP(I)-TT-SUM)/DEN
  502 IF(IKK-2) 62,63,64
   62 JL=NN1
      GO TO 65
   63 JL=NN2
      GO TO 65
   64 JL=NN3
   65 IF(I.LE.JL) GO TO 7
      D=ABS(RBP(JL+1)-RBP(JL))
      IF(D.GE.0.0001) GO TO 68
      C(JL+1)=C(JL)
      IKK=IKK+1
      GO TO 7
   68 C(JL+1)=(RBP(JL+1)-RBP(JL))/(RBP(JL+1)+BETA)
      IKK=IKK+1
    7 CONTINUE
C     I=2 IS 2ND POINT ON SURFACE
      DO 9 I=2,NN
```

```
      SUM1=0.
      SUM2=0.
      SUM3=0.
      SUM4=0.
      SUM5=0.
      SUM6=0.
C  J=1 IS CONICAL SOLN. WHICH WILL BE ADDED IN BELOW.
      DO 10 J=2,I
      XXI=XB(I)+BETA*RB(J-1)-XB(J-1)
      TAU=BETA*RB(I)/XXI
      IF(TAU.GE.1.) TAU=0.999999999
      F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
      SUM1=SUM1-C(J)*XXI**2*((1.+0.5*TAU**2)*F1 -1.5*F2)
      SUM2=SUM2-2.*C(J)*XXI*(F1-F2)
      SUM3=SUM3+BETA*C(J)*XXI*(F2/TAU-TAU*F1)
      SUM4=SUM4-2.*C(J)*F1
      SUM5=SUM5+2.*BETA*C(J)*F2/TAU
      SUM6=SUM6-BETA**2*C(J)*(F2/TAU**2 + F1)
   10 CONTINUE
      JH=NN1+1
      IF(I.LE.NN1) GO TO 18
      CALL DISC2
      J=NN1+1
      XXI=XB(I)+BETA*RB(J-1)-XB(J-1)
      TAU=BETA*RB(I)/XXI
      IF(TAU.GE.1.) TAU=0.999999999
      F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
      SUM1=SUM1+C(J)*XXI**2*((1.+0.5*TAU**2)*F1 -1.5*F2)
      SUM2=SUM2+2.*C(J)*XXI*(F1-F2)
      SUM3=SUM3-BETA*C(J)*XXI*(F2/TAU-TAU*F1)
      SUM4=SUM4+2.*C(J)*F1
      SUM5=SUM5-2.*BETA*C(J)*F2/TAU
      SUM6=SUM6+BETA**2*C(J)*(F2/TAU**2 + F1)
      JH=NN2+1
      IF(I.LE.NN2) GO TO 18
      CALL DISC2
      J=NN2+1
      XXI=XB(I)+BETA*RB(J-1)-XB(J-1)
      TAU=BETA*RB(I)/XXI
      IF(TAU.GE.1.) TAU=0.999999999
      F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
      SUM1=SUM1+C(J)*XXI**2*((1.+0.5*TAU**2)*F1 -1.5*F2)
      SUM2=SUM2+2.*C(J)*XXI*(F1-F2)
      SUM3=SUM3-BETA*C(J)*XXI*(F2/TAU-TAU*F1)
      SUM4=SUM4+2.*C(J)*F1
      SUM5=SUM5-2.*BETA*C(J)*F2/TAU
      SUM6=SUM6+BETA**2*C(J)*(F2/TAU**2 + F1)
      JH=NN3+1
      IF(I.LE.NN3) GO TO 18
      CALL DISC2
      J=NN3+1
      XXI=XB(I)+BETA*RB(J-1)-XB(J-1)
```

```
      TAU=BETA*RB(I)/XXI
      IF(TAU.GE.1.) TAU=0.999999999
      F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
      SUM1=SUM1+C(J)*XXI**2*((1.+0.5*TAU**2)*F1 -1.5*F2)
      SUM2=SUM2+2.*C(J)*XXI*(F1-F2)
      SUM3=SUM3-BETA*C(J)*XXI*(F2/TAU-TAU*F1)
      SUM4=SUM4+2.*C(J)*F1
      SUM5=SUM5-2.*BETA*C(J)*F2/TAU
      SUM6=SUM6+BETA**2*C(J)*(F2/TAU**2 + F1)
   18 XIMX1=XB(I)-XB(1) +BETA*RB(1)
      TAU=BETA*RB(I)/XIMX1
      IF(TAU.GE.1.) TAU=0.999999999
      F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
      ZE0(I)=SUM1+XIMX1*(F2-F1)*C(1)
      ZE0X(I)=SUM2-F1*C(1)
      ZE0R(I)=SUM3+BETA*F2/TAU*C(1)
      ZE0XX(I)=-1./(XIMX1*F2)*C(1)+SUM4
      ZE0XR(I)=BETA/(XIMX1*TAU*F2)*C(1)+SUM5
      ZE0RR(I)=-BETA**2/(XIMX1*TAU**2*F2)*C(1)+SUM6
      QB=(1.+ZE0X(I))**2 + ZE0R(I)**2
      CP01=2./(1.4*VOVS**2)*((1.+0.2*VOVS**2*(1.-QB))**3.5 - 1.)
      CPV(I,1)=CP01
      PHIX(I)=ZE0X(I)
      PHIR(I)=ZE0R(I)
      IF(NSHAPE.NE.4) GO TO 503
      IF(I.GT.NN2) GO TO 505
      GO TO 504
  503 IF(I.GT.NN3) GO TO 505
  504 CONTINUE
C    SECOND ORDER AXIAL SOLUTION.
C     A. PARTICULAR SOLUTION
      AN=1.2*VOVS**2/BETA**2
      PSI(I)=VOVS**2*(ZE0X(I)*(ZE0(I)+AN*RB(I)*ZE0R(I))-0.25*RB(I)
     1*ZE0R(I)**3)
      PSIX(I)=VOVS**2*((ZE0(I) +AN*RB(I)*ZE0R(I))*ZE0XX(I) + ZE0X(I)*(
     1ZE0X(I)+AN*RB(I)*ZE0XR(I))-0.75*RB(I)*ZE0R(I)**2*ZE0XR(I))
      PSIR(I)=VOVS**2*((ZE0(I)+AN*RB(I)*ZE0R(I))*ZE0XR(I)+ZE0X(I)*((AN
     1+1.)*ZE0R(I)+AN*RB(I)*ZE0RR(I))-0.25*ZE0R(I)**2*(ZE0R(I)+3.*RB(I)
     2*ZE0RR(I)))
C     B. COMPLIMENTARY SOLUTION
   20 SUM=0.
      IF(I.EQ.2) GO TO 37
      J3=I-1
      DO 12 J=2,J3
      XI=XB(J-1)-BETA*RB(J-1)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.999999999
      SUM=SUM+BETA*C1(J)*(XB(I)-XI          )*(SQRT(1.-TAU**  )/TAU
     1-TAU*ARSECH(TAU))
   12 CONTINUE
      JH=NN1+1
      IF(I.LE.JH ) GO TO 37
      CALL
```

```
      J=NN1+1
      XI=XB(J-1)-BETA*RB(J-1)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.999999999
      SUM=SUM-BETA*C1(J)*(XB(I)-XI                    )*(SQRT(1.-TAU**2)/TAU
     1-TAU*ARSECH(TAU))
      JH=NN2+1
      IF(I.LE.JH ) GO TO 37
      CALL DISC3
      J=NN2+1
      XI=XB(J-1)-BETA*RB(J-1)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.999999999
      SUM=SUM-BETA*C1(J)*(XB(I)-XI                    )*(SQRT(1.-TAU**2)/TAU
     1-TAU*ARSECH(TAU))
      JH=NN3+1
      IF(I.LE.JH ) GO TO 37
      CALL DISC3
      J=NN3+1
      XI=XB(J-1)-BETA*RB(J-1)
      TAU=BETA*RB(I)/(XB(I)-XI)
      IF(TAU.GE.1.) TAU=0.999999999
      SUM=SUM-BETA*C1(J)*(XB(I)-XI                    )*(SQRT(1.-TAU**2)/TAU
     1-TAU*ARSECH(TAU))
   37 TAU=BETA*RB(I)/(XB(I)-XB(I-1)+BETA*RB(I-1))
      IF(TAU.GE.1.) TAU=0.999999999
      TAU1=BETA*RB(I)/(XB(I)-XB(1)+BETA*RB(1))
      TT=C1(1)*BETA*SQRT(1.-TAU1**2)/ TAU1
      C1(I)=(RBP(I)*(1.+ZEOX(I))-PSIR(I)-TT-SUM)/(BETA*(XB(I)-
     1XB(I-1)+BETA*RB(I-1))*(SQRT(1.-TAU**2)/TAU-TAU*ARSECH(TAU)))
      IF(IK-2) 94,95,96
   94 JL=NN1
      GO TO 97
   95 JL=NN2
      GO TO 97
   96 JL=NN3
   97 IF(I.LE.JL) GO TO 93
      D=ABS(RBP(JL+1)-RBP(JL))
      IF(D.LE.0.0001) GO TO 92
      D1=PSI(JL+1)-PSI(JL)
      C3=-D1
      C1(JL+1)=(RBP(JL+1)*(1.+ZEOX(JL+1))-PSIR(JL+1)-TT-SUM+3.*C3/
     1(8.*RB(JL+1)))/BETA
      IK=IK+1
      GO TO 93
   92 C1(JL+1)=(RBP(JL+1)*(1.+ZEOX(JL+1))-PSIR(JL+1)-TT-SUM)/BETA
      IK=IK+1
   93 SUM1=0.
      SUM2=0.
      SUM3=0.
      DO 13 J=2,I
      XXI=XB(I)-XB(J-1)+BETA*RB(J-1)
      TAU=BETA*RB(I)/XXI
      IF(TAU.GE.1.) TAU=0.999999999
      F1=ARSECH(TAU)
```

```
      F2=SQRT(1.-TAU**2)
      SUM1=SUM1-C1(J)*XXI**2*((1.+0.5*TAU**2)*F1-1.5*F2)
      SUM2=SUM2-2.*C1(J)*XXI*(F1-F2)
      SUM3=SUM3+BETA*C1(J)*(F2/TAU-TAU*F1)*XXI
   13 CONTINUE
      JH=NN1+1
      IF(I.LE.NN1) GO TO 21
      CALL DISC4
      J=NN1+1
      XXI=XB(I)-XB(J-1)+BETA*RB(J-1)
      TAU=BETA*RB(I)/XXI
      IF(TAU.GE.1.) TAU=0.999999999
      F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
      SUM1=SUM1+C1(J)*XXI**2*((1.+0.5*TAU**2)*F1-1.5*F2)
      SUM2=SUM2+2.*C1(J)*XXI*(F1-F2)
      SUM3=SUM3-BETA*C1(J)*(F2/TAU-TAU*F1)*XXI
      JH=NN2+1
      IF(I.LE.NN2) GO TO 21
      CALL DISC4
      J=NN2+1
      XXI=XB(I)-XB(J-1)+BETA*RB(J-1)
      TAU=BETA*RB(I)/XXI
      F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
      SUM1=SUM1+C1(J)*XXI**2*((1.+0.5*TAU**2)*F1-1.5*F2)
      SUM2=SUM2+2.*C1(J)*XXI*(F1-F2)
      SUM3=SUM3-BETA*C1(J)*(F2/TAU-TAU*F1)*XXI
      JH=NN3+1
      IF(I.LE.NN3) GO TO 21
      CALL DISC4
      J=NN3+1
      XXI=XB(I)-XB(J-1)+BETA*RB(J-1)
      TAU=BETA*RB(I)/XXI
      IF(TAU.GE.1.) TAU=0.999999999
      F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
      SUM3=SUM3-BETA*C1(J)*(F2/TAU-TAU*F1)*XXI
      SUM2=SUM2+2.*C1(J)*XXI*(F1-F2)
      SUM1=SUM1+C1(J)*XXI**2*((1.+0.5*TAU**2)*F1-1.5*F2)
   21 XIMX1=XB(I)-XB(1)  +BETA*RB(1)
      TAU=BETA*RB(I)/XIMX1
      IF(TAU.GE.1.) TAU=0.999999999
      F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
      ZFOP(I)=SUM1+C1(1)*XIMX1*(F2-F1)
      ZFOPX(I)=SUM2-C1(1)*F1
      ZFOPR(I)=SUM3+C1(1)*BETA*F2/TAU
C     TOTAL 2ND ORDER SOLN.=PARTICULAR PLUS COMPLEMENTARY.
      PHI(I)=PSI(I)+ZFOP(I)
      PHIX(I)=PSIX(I)+ZFOPX(I)
      PHIR(I)=PSIR(I)+ZFOPR(I)
      QR=(1.+PHIX(I))**2 + PHIR(I)**
      CPV(I,1)=2./(1.4*VOVT**2)*(((1.+2.*...
      ...=CPV(I,1)
```

```
 505  IF(IPRINT.NE.1) GO TO 9
 42   FORMAT(47X,6F10.5)
   9  CONTINUE
 35   IF(ABS(AL).GT.0.001) GO TO 116
      IF(IPRINT.NE.1) GO TO 151
      WRITE(6,41)
 41   FORMAT(54X,1HX,10X,1HR,10X,5HDR/DX,7X,3HCP ,/)
 151  DO 117 I=1,NN
      IF(IPRINT.NE.1) GO TO 150
      WRITE(6,42) XB(I),RB(I),RBP(I),CPV(I,1)
 150  DO 117 J=1,7
      CPV(I,J)=CPV(I,1)
 117  CONTINUE
      GO TO 108
C     FIRST ORDER CROSS FLOW
 116  IF(IPRINT.NE.1) GO TO 120
      WRITE(6,51)
 51   FORMAT(54X,1HX,8X,1HR,9X,5HTHETA,6X,2HCP,//)
 120  J=1
C      BOUNDARY LAYER DISPLACEMENT THICKNESS INCLUDED FOR CROSSFLOW SOLUTION.
      PO=(1.+.0092*VOVS**2)**0.38
      RND=RN*DIA
      XCRIT=500000./RND
      DELI=0.125*PO*5.*SQRT(XCRIT/RND)
      DEL1=(5.*SQRT(XCRIT/RND))**1.25
      DEL2=0.
      DRBP=0.
      DO 702 I=2,NN
      IF(XB(I).GT.0.) GO TO 705
      RB1(I)=RB(I)
      RBP1(I)=RBP(I)
      GO TO 702
 705  IF(XB(I).LE.XCRIT) GO TO 700
      DEL=.125*PO*(DEL1+0.289*(XB(I)-XCRIT)/RND**0.25)**0.80
      GO TO 701
 700  DEL=DELI*XB(I)/XCRIT
 701  CONTINUE
      RB1(I)=RB (I)+DEL
      DER=DEL-DEL2
      DEX=XB(I)-XB(I-1)
      IF(DEX.GT.0.) GO TO 703
      GO TO 704
 703  DRBP=DER/DEX
 704  RBP1(I)=RBP (I)+DRBP
      DEL2=DEL
 702  CONTINUE
      RB1(1)=RB(1)
      RBP1(1)=RBP1(2)
      TA=RBP1(1)
      TA2=TA**2
      B(1)=2./BETA/(SQRT(1.-BETA**2*TA2)/(BETA**2*TA2)+ARSECH(BETA*TA))
      I=1
      TAU=BETA*TA
      F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
```

```
      ZE1(1)=B(1)/2.*(F2/TAU-TAU*F1)
      ZE1X(1)=B(1)*F2/TAU
      ZE1R(1)=-BETA*B(1)/2.*(F2/TAU**2+F1)
      DO 53 IJ=1,7
      UB=COS(AL)*(1.+PHIX(I))+SIN(AL)*COS(THET(IJ))*ZE1X(I)
      VB=COS(AL)*PHIR(I)+SIN(AL)*COS(THET(IJ))*(1.+ZE1R(I))
      WB=-SIN(AL)*SIN(THET(IJ))*(1.+ZE1(I)/TA)
      QB=UB**2+VB**2+WB**2
      CPV(1,IJ)=2./(1.4*VOVS**2)*((1.+0.2*VOVS**2*(1.-QB))**3.5-1.)
      IF(IPRINT.NE.1) GO TO 53
      WRITE(6,42) XB(I),RB(I),THET1(IJ),CPV(1,IJ)
53    CONTINUE
      IF(NN.NE.2) GO TO 23
      DO 131 IJ=1,7
      CPV(2,IJ)=CPV(1,IJ)
131   CONTINUE
      GO TO 108
23    J5=NN
      DO 22 I=2,J5
      SUM=0.
      J6=I-1
      DO 14 J=1,J6
      IF(J.GT.1) GO TO 110
      TAU=BETA*RB1(I)/(XB(I)-XB(1)+BETA*RB(1))
      IF(TAU.GE.1.) TAU=0.999999999
      GO TO 111
110   T U=BETA*RB1(I)/(XB(I)-XB(J-1)+BETA*RB1(J-1))
      IF(TAU.GE.1.) TAU=0.999999999
111   F1=ARSECH(TAU)
      F2=SQRT(1.-TAU**2)
      IF(J.EQ.1) GO TO 107
      D=ABS(XB(J)-XB(J-1))
      IF(D.LT.0.000001) GO TO 14
107   SUM=SUM-B(J)*(F2/TAU**2+F1)
14    CONTINUE
      TAU=BETA*RB1(I)/(XB(I)-XB(I-1)+BETA*RB1(I-1))
      IF(TAU.GE.1.) TAU=0.999999999
      D=ABS(XB(I)-XB(I-1))
      IF(D.LT.0.000001) GO TO 114
      B(I)=(2./BETA+SUM)/(SQRT(1.-TAU**2)/TAU**2+ARSECH(TAU))
      GO TO 115
114   B(I)=0.
115   SUM1=0.
      SUM2=0.
      SUM3=0.
      DO 15 J=1,I
      IF(J.GT.1) GO TO 112
      TAU=BETA*RB1(I)/(XB(I)-XB(1)+BETA*RB(1))
      IF(TAU.GE.1.) TAU=0.999999999
      XXI=XB(I)-XB(1)   +BETA*RB(1)
      GO TO 113
112   XXI=XB(I)-XB(J-1)+BETA*RB1(J-1)
      TAU=BETA*RB1(I)/XXI
      IF(TAU.GE.1.) TAU=0.999999999
113   F1=ARSECH(TAU)
```

```
      F2=SQRT(1.-TAU**2)
   24 SUM1=SUM1+B(J)/2.*(F2/TAU-TAU*F1)*XXI
      SUM2=B(J)*F2/TAU+SUM2
      SUM3=-BETA/2.*B(J)*(F2/TAU**2+F1)+SUM3
      IF(I.EQ.1) GO TO 46
   15 CONTINUE
   46 ZE1(I)=SUM1
      ZE1X(I)=SUM2
      ZE1R(I)=SUM3
C  HYBRID THEORY
      DO 48 IJ=1,7
      UB=COS(AL)*(1.+PHIX(I))+SIN(AL)*COS(THET(IJ))*ZE1X(I)
      VB=COS(AL)*PHIR(I)+SIN(AL)*COS(THET(IJ))*(1.+ZE1R(I))
      WB=-SIN(AL)*SIN(THET(IJ))*(1.+ZE1(I)/RB1(I))
      QB=UB**2+VB**2+WB**2
      CPV(I,IJ)=2./(1.4*VOVS**2)*((1.+0.2*VOVS**2*(1.-QB))**3.5-1.)
      IF(IPRINT.NE.1) GO TO 48
      WRITE(6,42) XB(I),RB(I),THET1(IJ),CPV(I,IJ)
   48 CONTINUE
      IF(N.EQ.2) GO TO 27
   22 CONTINUE
  108 IF(NBLUNT.EQ.2) CALL NEWT
      CALL WAVE
   27 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE INTERP(TX,TY,X,Y,N,J)
      DIMENSION TX(100),TY(100)
      I=0
    1 I=I+1
      IF(TX(I).LE.X) GO TO 1
      IF(I.LE.J) I=J
      IF(I.GT.(N-2)) I=N-2
      CALL INTER5(X,TX(I-2),TX(I-1),TX(I),TX(I+1),TX(I+2),TY(I-2),TY(I-1
     1),TY(I),TY(I+1),TY(I+2),Y)
      RETURN
      END
```

```
      SUBROUTINE INTERP5(X,X1,X2,X3,X4,X5,F1,F2,F3,F4,F5,F)
C     5 POINT LAGRANGE INTERPOLATION SUBROUTINE
C     X1.LE.X.LE.X5
      A1=(X-X2)*(X-X3)*(X-X4)*(X-X5)
      A2=(X-X1)*(X-X3)*(X-X4)*(X-X5)
      A3=(X-X1)*(X-X2)*(X-X4)*(X-X5)
      A4=(X-X1)*(X-X2)*(X-X3)*(X-X5)
      A5=(X-X1)*(X-X2)*(X-X3)*(X-X4)
      D1=(X1-X2)*(X1-X3)*(X1-X4)*(X1-X5)
      D2=(X2-X1)*(X2-X3)*(X2-X4)*(X2-X5)
      D3=(X3-X1)*(X3-X2)*(X3-X4)*(X3-X5)
      D4=(X4-X1)*(X4-X2)*(X4-X3)*(X4-X5)
      D5=(X5-X1)*(X5-X2)*(X5-X3)*(X5-X4)
      C1=A1/D1
      C2=A2/D2
      C3=A3/D3
      C4=A4/D4
      C5=A5/D5
      F=C1*F1+C2*F2+C3*F3+C4*F4+C5*F5
      RETURN
      END
```

```
      SUBROUTINE LIFT(B,GAMA,CR,CT,XLE,XL,DELTA,IOP,IOP1,TR,TT,K,AREF,DF
     1)
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NBLUNT,NN,NNT,IPRINT,NN1A
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,NNTA
      COMMON/F/CNRF,CNTB,CNBT,CMRF,CMBT,CMTB
      COMMON/G/ CNC,CNFB,CNBF,CMFB,CMBF,CMC,CNTV,CMTV
      COMMON/BASE/CAB,CNB,CMB,TOC,XOC,NTYPE
C     IOP=1 FOR WING
C     IOP=2 FOR TAIL
C     IF JUST HAVE WING OR JUST HAVE TAIL IOP1=1
C     K MUST BE INITIALIZED TO ZERO FOR EACH NEW CONFIGURATION
      XM=CR*.25
      DREF=SQRT(4.*AREF/3.14159)
      IF(NTYPE.EQ.4) DREF=CR
      XL=XL*DREF
      XLE=XLE*DREF
      DELTA1=DELTA/57.29578
      YBAR=B/6.*(CR+2.*CT)/(CR+CT)
      TBAR=TR-(TR-TT)/(.5*B)*YBAR
      CBAR=CR-(CR-CT)*(CR+2.*CT)/(3.*(CR+CT))
      TOVC=TBAR/CBAR
      N1=4
      N2=4
      N4=3
      ALAM=CT/CR
      BETA=SQRT(ABS(VOVS**2-1.))
      AI=AL*57.29578
      XL1=XLE+CR+DF*BETA
      IF(XL-XL1) 500,500,600
  500 XAFT=XL-(XLE+CR)
      GO TO 601
  600 XAFT=DF*BETA
  601 CONTINUE
      SF=(CR+CT)*.5*B
      ARF=2.*B/(CR+CT)
      R=.5*DF
      IF(VOVS-.79) 104,105,105
  104 CALL SUBCNA(B,CR,CT,GAMA,SF,AI,XLE,CNAF,XCPF,VOVS,N1,N2,N4)
      GO TO 108
  105 IF(VOVS-1.19) 106,106,107
  106 CALL TRNCNA(CR,CT,B,GAMA,TOVC,VOVS,CNAF,XCPF,IOP,K,SF,AI,XLE,N1,N2
     1,N4)
      GO TO 108
  107 CALL SUPCNA(CR,CT,B,VOVS,AI,IPRINT,GAMA,XLE,SF,1.,CNAF,XCPF,IOP)
  108 CONTINUE
C     FIN BODY INTERFERENCE
      Q=.5*B+R
      CALL FBINT(R,Q,VOVS,CR,CT,ARF,GAMA,CNAF,XKFB,XKBF,XKFB1,XKBF1,XL,X
     1LE,AREF)
      IF(NTYPE.NE.4) GO TO 200
      XKFB=1.
      XKFB1=1.
      XKBF=0.
      XKBF1=0.
  200 IF(IOP1.LE.1) GO TO 111
```

```
      IF(1-IOP) 109,110,110
  109 PT=P
      ST=SF
      BT=B
      ART=AREF
      CNAT=CNAF
      XCPT=XCPF
      ALAMT=ALAM
      XKTB=XKFB
      XKBT=XKBF
      XKTB1=XKFB1
      XKBT1=XKBF1
      DELTAT=DELTA/57.29578
      IF(VOVS.GT.1.19) GO TO 216
      XCPBT=XCPT/DREF
      GO TO 209
  216 F1=BETA*DREF-XAFT
      F2=F1-CR
      IF(F1.GE.0.) GO TO 201
      XCPBT=(CR+BETA*DREF)/2.
      XCPBT=XCPBT/DREF+XLE/DREF
      GO TO 209
  201 IF(F2.GT.0.) GO TO 205
      C1=CR**2*DREF/2.
      C2=BETA**2*DREF**3/6.
      C3=(DREF/2.-XAFT/(3.*BETA))/(DREF-XAFT/(2.*BETA))
      C4=CR+XAFT*C3
      C5=XAFT*C4*(2.*DREF-XAFT/BETA)/2.
      C6=DREF*CR-BETA*DREF**2/2.
      C7=XAFT*(2.*DREF-XAFT/BETA)/2.
      XCPBT=(C1-C2+C5)/(C6+C7)
      XCPBT=XCPBT/DREF+XLE/DREF
      GO TO 209
  205 C1=CR+XAFT
      C2=CR+2.*XAFT/3.
      XCPBT=(2.*C1**3/3.-C2*XAFT**2)/(C1**2-XAFT**2)
      XCPBT=XCPBT/DREF+XLE/DREF
  209 XCPTB=XCPT/DREF
      GO TO 112
  110 CALL WTINT(R,B,RT,BT,ART,CNAF,CNAT,CR,XCPT,XLE,DELTA1,ALAMT,XH,XKF
     1B,XKFB1,CLTVA,AI)
      CNFB=CNAF*(XKFB*AL+XKFB1*DELTA1)*SF/AREF
      CNBF=CNAF*(XKBF*AL+XKBF1*DELTA1)*SF/AREF
      CNTB=CNAT*(XKTB*AL+XKTB1*DELTAT)*ST/AREF
      CNBT=CNAT*(XKBT*AL+XKBT1*DELTAT)*ST/AREF
      CNTV=CLTVA*SF/AREF
      XCPCB=XCPF/DREF
      IF(VOVS.GT.1.19) GO TO 215
      XCPBC=XCPCB
      GO TO 211
  215 F1=BETA*DREF-XAFT
      F2=F1-CR
      IF(F1.GE.0.) GO TO 203
      XCPBC=(CR+BETA*DREF)/2.
      XCPBC=XCPBC/DREF+XLE/DREF
```

```
      GO TO 211
  203 IF(F2.GT.0.) GO TO 207
      C1=CR**2*DREF/2.
      C2=BETA**2*DREF**3/6.
      C3=(DREF/2.-XAFT/(3.*BETA))/(DREF-XAFT/(2.*BETA))
      C4=CR+XAFT*C3
      C5=XAFT*C4*(2.*DREF-XAFT/BETA)/2.
      C6=DREF*CR-BETA*DREF**2/2.
      C7=XAFT*(2.*DREF-XAFT/BETA)/2.
      XCPBC=(C1-C2+C5)/(C6+C7)
      XCPBC=XCPBC/DREF+XLE/DREF
      GO TO 211
  207 C1=CR+XAFT
      C2=CR+2.*XAFT/3.
      XCPBC=(2.*C1**3/3.-C2*XAFT**2)/(C1**2-XAFT**2)
      XCPBC=XCPBC/DREF+XLE/DREF
  211 CMFB=-CNFB*XCPCB
      CMBF=-CNBF*XCPBC
      CMTB=-CNTB*XCPTB
      CMBT=-CNBT*XCPBT
      CMTV=-CNTV*XCPTB
      CNRF=CNAT*AL*ST/AREF
      CMRF=-CNRF*XCPTB
      CNC=CNAF*AL*SF/AREF
      CMC=-CNC*XCPCB
      GO TO 112
  111 CONTINUE
      IF(IOP-1) 113,113,114
  113 CNFB=CNAF*(XKFB*AL+XKFB1*DELTA1)*SF/AREF
      CNBF=CNAF*(XKBF*AL+XKBF1*DELTA1)*SF/AREF
      CNTB=0.
      CNBT=0.
      CNTV=0.
      XCPTB=0.
      XCPBT=0.
      XCPCB=XCPF/DREF
      F1=BETA*DREF-XAFT
      F2=F1-CR
      IF(F1.GE.0.) GO TO 204
      XCPBC=(CR+BETA*DREF)/2.
      XCPBC=XCPBC/DREF+XLE/DREF
      GO TO 210
  204 IF(F2.GT.0.) GO TO 208
      C1=CR**2*DREF/2.
      C2=BETA**2*DREF**3/6.
      C3=(DREF/2.-XAFT/(3.*BETA))/(DREF-XAFT/(2.*BETA))
      C4=CR+XAFT*C3
      C5=XAFT*C4*(2.*DREF-XAFT/BETA)/2.
      C6=DREF*CR-BETA*DREF**2/2.
      C7=XAFT*(2.*DREF-XAFT/BETA)/2.
      XCPBC=(C1-C2+C5)/(C6+C7)
      XCPBC=XCPBC/DREF+XLE/DREF
      GO TO 210
  208 C1=CR+XAFT
      C2=CR+2.*XAFT/3.
```

```
      XCPBC=(2.*C1**3/3.-C2*XAFT**2)/(C1**2-XAFT**2)
      XCPBC=XCPBC/DREF+XLE/DREF
  210 CMFB=-CNFB*XCPCB
      CMBF=-CNBF*XCPBC
      CMTB=0.
      CMBT=0.
      CMTV=0.
      CNRF=0.
      CMRF=0.
      CNC=CNAF*AL*SF/AREF
      CMC=-CNC*XCPCB
      GO TO 112
  114 CMFB=0.
      CNBF=0.
      CNTB=CNAF*(XKFB*AL+XKFB1*DELTA1)*SF/AREF
      CNBT=CNAF*(XKBF*AL+XKBF1*DELTA1)*SF/AREF
      CNTV=0.
      XCPCB=0.
      XCPBC=0.
      XCPTB=XCPF/DREF
      IF(VOVS.GT.1.19) GO TO 217
      XCPBT=XCPTB
      GO TO 212
  217 F1=BETA*DREF-XAFT
      F2=F1-CR
      IF(F1.GE.0.) GO TO 202
      XCPBT=(CR+BETA*DREF)/2.
      XCPBT=XCPBT/DREF+XLE/DREF
      GO TO 212
  202 IF(F2.GT.0.) GO TO 206
      C1=CR**2*DREF/2.
      C2=BETA**2*DREF**3/6.
      C3=(DREF/2.-XAFT/(3.*BETA))/(DREF-XAFT/(2.*BETA))
      C4=CR+XAFT*C3
      C5=XAFT*C4*(2.*DREF-XAFT/BETA)/2.
      C6=DREF*CR-BETA*DREF**2/2.
      C7=XAFT*(2.*DREF-XAFT/BETA)/2.
      XCPBT=(C1-C2+C5)/(C6+C7)
      XCPBT=XCPBT/DREF+XLE/DREF
      GO TO 212
  206 C1=CR+XAFT
      C2=CR+2.*XAFT/3.
      XCPBT=(2.*C1**3/3.-C2*XAFT**2)/(C1**2-XAFT**2)
      XCPBT=XCPBT/DREF+XLE/DREF
  212 CMFB=0.
      CMBF=0.
      CMTB=-CNTB*XCPTB
      CMBT=-CNBT*XCPBT
      CMTV=0.
      CNC=0.
      CMC=0.
      CNRF=CNAF*AL*SF/AREF
      CMRF=-CNRF*XCPTB
  112 CONTINUE
      XLE=XLE/DREF
```

```
      XL=XL/DREF
      RETURN
      END
```

```
      SUBROUTINE MINVR(A,N,B,M,DETERM,IERR)                          MIV   0
CMINVR MATRIX INVERSION FOR STRETCH WITH VARIABLE ARRAY SIZE         MIV  10
C                                                                    MIV  20
      DIMENSION IPIVOT(100),INDEX(100,2)                             MIV  30
      DIMENSION A(N,N),B(N,M)                                        MIV  40
C                                                                    MIV  50
C     ERROR LIST                                                     MIV  60
C     7001 - N GREATER THAN 100                                      MIV  70
C     7002 - REMAINDER OF MATRIX HAS VANISHED                        MIV  80
C                                                                    MIV  90
      EQUIVALENCE (AMAX,T,SWAP)                                      MIV 100
C                                                                    MIV 110
C     CONSISTENCY CHECK                                              MIV 120
C                                                                    MIV 130
    4 IERR=0                                                         MIV 140
    5 IF(N-100)10,10,6                                               MIV 150
    6 IERR=7001                                                      MIV 160
      RETURN                                                         MIV 170
C                                                                    MIV 180
C     INITIALIZATION                                                 MIV 190
C                                                                    MIV 200
   10 DETERM=1.0                                                     MIV 210
   15 DO 20 J=1,N                                                    MIV 220
   20 IPIVOT(J)=0                                                    MIV 230
   30 DO 550 I=1,N                                                   MIV 240
C                                                                    MIV 250
C     SEARCH FOR PIVOT ELEMENT                                       MIV 260
C                                                                    MIV 270
   40 AMAX=0.0                                                       MIV 280
   45 DO 105 J=1,N                                                   MIV 290
   50 IF (IPIVOT(J)-1) 60, 105, 60                                   MIV 300
   60 DO 100 K=1,N                                                   MIV 310
   70 IF(IPIVOT(K)-1)80,100,100                                      MIV 320
   80 IF (ABS (AMAX)-ABS (A(J,K))) 85, 100, 100                      MIV 330
   85 IROW=J                                                         MIV 340
   90 ICOLUM=K                                                       MIV 350
   95 AMAX=A(J,K)                                                    MIV 360
  100 CONTINUE                                                       MIV 370
  105 CONTINUE                                                       MIV 380
  110 IPIVOT(ICOLUM)=1                                               MIV 390
  112 IF(AMAX)130,113,130                                            MIV 400
  113 IERR=7002                                                      MIV 410
      RETURN                                                         MIV 420
C                                                                    MIV 430
C     INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL              MIV 440
C                                                                    MIV 450
  130 IF (IROW-ICOLUM) 140, 260, 140                                 MIV 460
  140 DETERM=-DETERM                                                 MIV 470
  150 DO 200 L=1,N                                                   MIV 480
  160 SWAP=A(IROW,L)                                                 MIV 490
  170 A(IROW,L)=A(ICOLUM,L)                                          MIV 500
  200 A(ICOLUM,L)=SWAP                                               MIV 510
  205 IF(M) 260, 260, 210                                            MIV 520
  210 DO 250 L=1, M                                                  MIV 530
  220 SWAP=B(IROW,L)                                                 MIV 540
```

```
      230 B(IROW,L)=B(ICOLUM,L)                                    MIV  550
      250 B(ICOLUM,L)=SWAP                                         MIV  560
      260 INDEX(I,1)=IROW                                          MIV  570
      270 INDEX(I,2)=ICOLUM                                        MIV  580
      310 PIVOT=A(ICOLUM,ICOLUM)                                   MIV  590
      320 DETERM=DETERM*PIVOT                                      MIV  600
C                                                                  MIV  610
C         DIVIDE PIVOT ROW BY PIVOT ELEMENT                        MIV  620
C                                                                  MIV  630
      330 A(ICOLUM,ICOLUM)=1.0                                     MIV  640
      340 DO 350 L=1,N                                             MIV  650
      350 A(ICOLUM,L)=A(ICOLUM,L)/PIVOT                            MIV  660
      355 IF(M) 380, 380, 360                                      MIV  670
      360 DO 370 L=1,M                                             MIV  680
      370 B(ICOLUM,L)=B(ICOLUM,L)/PIVOT                            MIV  690
C                                                                  MIV  700
C         REDUCE NON-PIVOT ROWS                                    MIV  710
C                                                                  MIV  720
      380 DO 550 L1=1,N                                            MIV  730
      390 IF(L1-ICOLUM) 400, 550, 400                              MIV  740
      400 T=A(L1,ICOLUM)                                           MIV  750
      420 A(L1,ICOLUM)=0.0                                         MIV  760
      430 DO 450 L=1,N                                             MIV  770
      450 A(L1,L)=A(L1,L)-A(ICOLUM,L)*T                            MIV  780
      455 IF(M) 550, 550, 460                                      MIV  790
      460 DO 500 L=1,M                                             MIV  800
      500 B(L1,L)=B(L1,L)-B(ICOLUM,L)*T                            MIV  810
      550 CONTINUE                                                 MIV  820
C                                                                  MIV  830
C         INTERCHANGE COLUMNS                                      MIV  840
C                                                                  MIV  850
      600 DO 710 I=1,N                                             MIV  860
      610 L=N+1-I                                                  MIV  870
      620 IF (INDEX(L,1)-INDEX(L,2)) 630, 710, 630                 MIV  880
      630 IROW=INDEX(L,1)                                          MIV  890
      640 ICOLUM=INDEX(L,2)                                        MIV  900
      650 DO 705 K=1,N                                             MIV  910
      660 SWAP=A(K,IROW)                                           MIV  920
      670 A(K,IROW)=A(K,ICOLUM)                                    MIV  930
      700 A(K,ICOLUM)=SWAP                                         MIV  940
      705 CONTINUE                                                 MIV  950
      710 CONTINUE                                                 MIV  960
      740 RETURN                                                   MIV  970
          END                                                      MIV  980
```

```
      SUBROUTINE NEWRAP(C7,RN,C6,F,CF1)
C     THIS SUBROUTINE USES NEWTON RAPHSON METHOD TO SOLVE FOR MEAN
C         SKIN FRICTION COEFFICIENT.
      CF=0.0025
      J=0
    1 F=C7/SQRT(CF)-ALOG10(RN*CF) +C6
      DFDCF=-.5*C7/(CF**1.5)-.43429/CF
      J=J+1
      CF1= CF
      CF=CF-F/DFDCF
      IF(CF.LE.0.0001) CF=0.0001
      DCF=CF-CF1
      IF(ABS(DCF)-1.E-05) 2,2,4
    4 IF(J-50) 1,1,2
    2 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE NEWT
      COMMON/GEOM/PP(6),X(30),R(30),C2,  ,  PE,N1,N2,XR(   ),RR(225)
      COMMON/GEO1/ RRR(225),BETA
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NPL   ,NN,NNT,IPRI   ,   A
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,NNTA
      COMMON/GEO4/K,F,RR,RREF
      COMMON/WAVE/CABL,CNBL,CMBL,CAW,CNW,CMW
      COMMON/CPV/ CPV(225,7),JA,JB
      DIMENSION PH(20),PHI(20)
      PLPI=(1.2*VOVS**2)**3.5*(6./(7.*VOVS**2-1.))**2.5
      IF(NFL.EQ.1) GO TO 2
      CP0= (0.906*PLPI-1.)/(0.7*VOVS**2)
      IF(IPRINT.NE.1) GO TO 19
      WRITE(6,6) CP0
    6 FORMAT(1X,40HPRESSURE COEFFICIENT ON TRUNCATED NOSE =,F10.5)
   19 CA=CP0*(R(1)/RREF)**2
      CN=0.
      CM=0.
      CABL=CA
      CNBL=0.
      CMBL=0.
      XCP=0.
      CL=-CA*SIN(AL)
      CD=CA*COS(AL)
      IF(NFL.EQ.2) GO TO 20
      NNI=2
      GO TO 99
    2 CP0=(PLPI-1.)/(0.7*VOVS**2)
      CS=COS(AL)
      SS=SIN(AL)
      PH(1)=0.
      PHI(1)=0.
      IF(AL.GT.0.0001) GO TO 9
      NM=1
      GO TO 10
    9 DO 3 I=2,7
      PHI(I)=PHI(I-1)+30.
      PH(I)=PHI(I)/57.29583
    3 CONTINUE
      NM=7
   10 IF(IPRINT.NE.1) GO TO 18
      WRITE(6,8)
    8 FORMAT(//,54X,*PRESSURE COEFFICIENTS ON SPHERICAL NOSE*,//)
   18 X1=0.
      DX=(RR+XM   )/6.
      DO 4 I=1,7
      X2=X1-RR
      R2=SQRT(RR**2-X2**2)
      DO 11  L=1,NM
      A=(1.-X1    /RR)**2
      CP    =CP0*(A*CS**2+(X1    /RR-1.)*S   ( .-A)*COS(PH(L))   IN(2.*AL)
     1+(1.-A)*COS(PH(L))**2*SS**2)
      IF(IPRINT.NE.1) GO TO 11
      WRITE(6,5) X2,R2,PHI(L),CP
   11 CONTINUE
```

```
          X1=X1+DX
    4     CONTINUE
          D=CP-CPV(2,7)
          D2=D
          DO 12 I=3,NN1
          X2=XB(I)
          IF(X2.GE.XINT) GO TO 15
          X1=CP+X2
          IF(X1.GE.RR) X1=RR
          IF(X1.GE.RR) X2=RR
          R2=SQRT(RR**2-X2**2)
          DO 13 L=1,NM
          A=(1.-X1/RR)**2
          CP   =CP0*(A*CS**2+(X1   /RR-1.)*SQRT(1.-A)*COS(PH(L))*SIN(2.*AL)
         1+(1.-A)*COS(PH(L))**2*SS**2)
          IF(IPRINT.NE.1) GO TO 13
          IF(I.LT.NN1) GO TO 13
          WRITE(6,5) X2,R2,PHI(L),CP
   13     CONTINUE
          IF(D.GT.0.) GO TO 14
          D1=D2
          D2=CP-CPV(I,7)
          IF(D2.LE.0.) GO TO 12
          SLOPE=(D2-D1)/(XB(I)-XB(I-1))
          XNV= XB(I-1)-D1/SLOPE
          NNI=I
          GO TO 15
   14     D1=D2
          D2=CP-CPV(I,7)
          IF(D2.GE.0.)GO TO 12
          SLOPE=(D2-D1)/(XB(I)-XB(I-1))
          XNV=XB(I-1)-D1/SLOPE
          NNI=I
          GO TO 15
   12     CONTINUE
   15     IF(I.GE.NN1) XNV=XINT
          NNI=I
          IF(X2.GE.XINT) XNV=XINT
          IF(I.GE.NN1) NNI=I-1
          YNV=SQRT(RR**2-XNV**2)
          TH2=ATAN(-YNV/XNV)
          SH=SIN(TH2)
          CH=COS(TH2)
          RA=(RR/RREF)**2
          CA=CP0/2.*RA*(CS**2*(1.-CH**4)+.5*SS    **2*SH**4)
          CN=CP0*RA*SIN(2.*AL)*SH**4/4.
          CM=-CP0/2.*RA*SIN(2.*AL)*(SH**4/4.+SH**2*CH**3/5.+2./15.*(CH**3
         1-1.))
          CABL=CA
          CNBL=CN
          CMBL=CM
          CL=CN*CS-CA*SS
          CD=CA*CS+CN*SS
          XCP=-CM/CN
   20     CONTINUE
```

```
    5  FORMAT(54X,4F10.5)
   99  RETURN
       END
```

```
      SUBROUTINE NCRMEO
      COMMON/GEOM/RP(6),X(30),R(30),C2,NSHAPE,N1,N2,XB(225),RB(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NPLUNT,NN,NNI,IPRINT,NN1A
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,NNIA
      COMMON/GEO4/K,F,RR,RREF
      COMMON/WAVE/CABL,CNBL,CMBL,CAW,CNW,CMW
      COMMON/VOL/ VOL,CAF,CNF,CMF,RN,DIA,XP,AP,VOLN,CR,CT,RW,CAFWI
      COMMON/LENG/BL,ANL,ALA
      DIMENSION A1(10),A2(10),AM(10),F1(10),G1(10),F2(10),G2(10),FA(10)
     1,D04(10),D06(10),D07(10),D08(10),D09(10),D10(10),D12(10)
     2,D11(10),XCPLA(10)
      DATA(A1(I),I=1,10)/1.75,1.82,1.9,1.96,2.05,2.6,3.5,3.65,3.7,3.35/
      DATA(A2(I),I=1,10)/1.8,1.83,1.89,1.95,1.97,2.15,2.45,2.44,2.4,2.2/
      DATA(AM(I),I=1,10)/0.,.2,.4,.6,.68,.8,.94,.97,1.05,1.2/
      DATA(F1(I),I=1,10)/0.,.1,.2,.3,.45,.6,.75,.85,.925,1./
      DATA(G1(I),I=1,10)/3.35,3.48,3.6,3.65,3.5,2.6,1.75,1.46,1.35,1.28/
      DATA(F2(I),I=1,10)/0.,.25,.5,.65,.82,1.,1.25,1.5,2.,2.5/
      DATA(G2(I),I=1,10)/3.35,3.,2.56,2.25,1.83,1.3,1.02,.95,.85,.75/
      DATA(FA(I),I=1,10)/0.,.5,1.,1.5,2.,2.5,3.,4.,6.,10./
      DATA(D04(I),I=1,10)/0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
      DATA(D06(I),I=1,10)/0.,.03,.043,.05,.05,.05,.05,.05,.05,.05/
      DATA(D07(I),I=1,10)/0.,.08,.113,.133,.143,.148,.15,.15,.15,.15/
      DATA(D08(I),I=1,10)/0.,.12,.16,.186,.207,.223,.235,.248,.25,.252/
      DATA(D10(I),I=1,10)/0.,.175,.23,.265,.293,.31,.325,.337,.34,.34/
      DATA(D11(I),I=1,10)/0.,.097,.138,.16,.176,.186,.19,.195,.197,.197/
      DATA(D12(I),I=1,10)/0.,.097,.138,.16,.176,.186,.19,.195,.197,.197/
      DATA(XCPLA(I),I=1,10)/.5,.4,.342,.31,.29,.272,.26,.248,.245,.245/
      IF(BL.GE.0.02) GO TO 6
      CNALB=0.
      GO TO 2
    6 IF(VOVS.GT.1.) GO TO 1
      F11=SQRT(1.-VOVS**2)
      CALL INTERP(F1,G1,F11,G11,10,3)
      CNALB=-G11*(1.-4.*RB(NN)**2)
      GO TO 2
    1 F12=SQRT(VOVS**2-1.)
      CALL INTERP(F2,G2,F12,G12,10,3)
      CNALB=-G12*(1.-4.*RB(NN)**2)
    2 THE=ABS(RBP(NN1))
      IF(NN1A.EQ.2) THE=ABS(RBP(NN2))
      IF(NBLUNT.EQ.2) THE=ABS(RBP(NN2))
      CALL INTERP(AM,A1,VOVS,A11,10,3)
      CALL INTERP(AM,A2,VOVS,A22,10,3)
      CNALN=-A11*THE +A22
      IF(ALA.GT.0.01) GO TO 9
      CNALA=0.
      GO TO 4
    9 CALL INTERP(FA,D07,ALA,D071,10,3)
      CALL INTERP(FA,D08,ALA,D081,10,3)
      CALL INTERP(FA,D10,ALA,D101,10,3)
      CALL INTERP(FA,D06,ALA,D061,10,3)
      IF(VOVS.GE.0.8) GO TO 5
      D041=0.
      CALL INTER5(VOVS,.4,.6,.7,.8,1.,D041,D061,D071,D081,D101,CNALA)
```

```
      IF(VOVS.LT.0.6) CNALA=5.*D061*(VOVS-0.
      IF(VOVS.LT.0.4) CNALA=0.
      GO TO 4
    5 CALL INTERP(FA,D12,ALA,D121,10,3)
      D111=D121
      CALL INTER5(VOVS,.7,.8,1.,1.1,1.2,D071, D81,D101,D111,  1,CNALA)
    4 CNAL=CNALA+CNALN+CNALB
      XCPN=ANL-VCLN/(3.14159*PREF**2)
      XCPB=XB(NN)-BL/2.
      XCPB=BL*(1.-3.14159*(PREF**2-PREF*BL*ABS(PBP(NN))+BL**2/3.*
     1PBP(NN)**2))+ANL+ALA
      XCPA=ANL+ALA/2.
      CALL INTERP(FA,XCPLA,ALA,XCP1,10,3)
      XCP=XCP1*ALA
      XCPA=ANL+XCP
      CMAL=-(CNALN*XCPN+CNALA*XCPA+CNALB*XCPB)
      CNW=CNAL*AL
      CMW=CMAL*AL
      RETURN
      END
```

```
      SUBROUTINE PCPINT(PX1)
      DIMENSION DEFOUT(10),DEIN(10),Z(10),AQ(10),P(10),G(10),AP(10)
      COMMON/AERO4/RS1(10),RS2(20),S(20)
      COMMON/AERO5/GN1(10,10),GN2(10,10)
      COMMON/AERO6/QI12(20,20),QI21(20,20),PI11(10,10),PI22(10,10)
      COMMON/AEROA/NB,NA,MYES,X,IWING
      COMMON/AERO9/N1,N2,N4
      Z(1)=2.
      Z(2)=2.**3/6.
      Z(3)=2.**5/120.*4.
      Z(4)=2.**7/(120.*42.)*36.
      Z(5)=2.**9/(120.*42.*72.)*24.**2
      Z(6)=2.**11/(120.*42.*72.*110.)*120.**2
      Z(7)=2.**13/(120.*42.*72.*110.*12.*13.)*720.**2
      Z(8)=2.**15/(120.*42.*72.*110.*12.*13.*14.*15.)*(720.*7.)**2
      Z(9)=Z(8)*256./ (16.*17.)
      DO 702 JR=1,N1
      Y=RS1(JR)
      SQ=SQRT(1.-Y)
      AQ0=1./SQ*ALOG(ABS((1.+SQ)/(1.-SQ)))
      AQ(1)=2.+Y*AQ0
      PO=-1./Y-AQ0/2.
      P(1)=AQ0-1.5*AQ(1)
      DO 700 I= 2,9
      AI=I
      AQ(I)=Z(I)+Y*AQ(I-1)
  700 P(I)=AI*AQ(I-1)-(AI+0.5)*AQ(I)
      DO 701 J=1,N1
      PI11(J,JR)=GN1(1,J)*PO
      DO 701 I=2,N1
      PI11(J,JR)=PI11(J,JR)+GN1(I,J)*P(I-1)
  701 CONTINUE
      DO 831 J=1,N1
  831 PI11(J,JR)=PI11(J,JR)/S(1)**2
  702 CONTINUE
      DO 802 JR=1,N2
      KD=JR+N1
      Y=ABS(RS2(KD))
      SQ=SQRT(1.-Y)
      AQ0=1./SQ*ALOG(ABS((1.+SQ)/(1.-SQ)))
      AQ(1)=2.+Y*AQ0
      PO=-1./Y-AQ0/2.
      P(1)=AQ0-1.5*AQ(1)
      DO 800 I= 2,9
      AI=I
      AQ(I)=Z(I)+Y*AQ(I-1)
  800 P(I)=AI*AQ(I-1)-(AI+0.5)*AQ(I)
      DO 801 J=1,N2
      PI22(J,JR)=GN2(1,J)*PO
      DO 801 I=2,N2
      PI22(J,JR)=PI22(J,JR)+GN2(I,J)*P(I-1)
      LR=N1+N2
  801 CONTINUE
      DO 832 J=1,N2
  832 PI22(J,JR)=PI22(J,JR)/S(LR)**2
```

```
 802  CONTINUE
      VVV=0.0979
      DX2=DX1/20.
 91   K1=N1+1
      K2=N1+N2
      K4=N1
      K5=1
      K6=N1
      NGPAT=N1+1
      DO 10 JR=K1,K2
      DO 11 I =1,NGPAT
 11   DEIN(I)= 0.0
      DEIN(1)=0.000001
 12   DX=DX2
      IF(DEIN(1)-VVV)13,13,14
 14   DX=DX1
 13   DO 15 M1=1,4
      X=DEIN(1)
      DO 201 I=1,K4
 201  AP(I)=X**(I-1)
      DO 16 K=1,K4
      G(K)=0.0
      DO 16 I=1,K4
 16   G(K)=G(K)+GN1(I,K)*AP(I)
      BAD1=(ABS(RS2(JR))*S(JR)+X*S(1))**2
      SQ=SQRT(1.00001-X)
      DEOUT(1)=1.
      DO 17 K=2,NGRAT
 17   DEOUT(K)=G(K-1)*SQ/BAD1
      CALL RK(DEOUT,DEIN,DX,NGRAT,M1)
 15   CONTINUE
      IF(DEIN(1)-0.99)12,12,18
 18   DO 19 J=K5,K6
      KDUM=J+1
 19   QI12(J,JR)=DEIN(KDUM)
 10   CONTINUE
 92   K1=1
      K2=N1
      K4=N2
      K5=N1+1
      K6=N1+N2
      NGRAT=N2+1
      DO 20 JR=K1,K2
      DO 21 I =1,NGPAT
 21   DFIN(I)= 0.0
      DFIN(1)=0.000001
 22   DX=DX2
      IF(DFIN(1)-VVV)23,23,24
 24   DX=DX1
 23   DO 25 M1=1,4
      X=DFIN(1)
      DO 202 I=1,K4
 202  AP(I)=X**(I-1)
      DO 26 K=1,K4
      G(K)=0.0
```

```
      DO 26 I=1,K4
   26 G(K)=G(K)+GN2(I,K)*AP(I)
      RAD1=(ABS(PS1(JP))*S(JP)+X*S(K6))**
      SQ=SQRT(1.00001-X)
      DEOUT(1)=1.
      DO 27 K=2,NGRAT
   27 DEOUT(K)=G(K-1)*SQ/RAD1
      CALL RK(DEOUT,DEIN,DX,NGRAT,M1)
   25 CONTINUE
      IF(DEIN(1)-0.99)22,22,28
   28 DO 29 J=K5,K6
      KDUM=J+1-N1
   29 DI21(J,JP)=DEIN(KDUM)
   20 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE BRAND
      COMMON/BAND/CAP,CNP,CMP,HB
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,AN
      DIMENSION AM(15),DCAP(15)
      DATA(AM(I),I=1,12)/0.,.5,.7,.8,.9,.95,1.,1.1,1.2,1.5,2.,2.5,3.0/
      DATA(DCAP(I),I=1,12)/0.,0.,0.,.001,.005,.01,.0092,.0075,.0067,
     1.0055,.0052,.005/
      CALL INTERP(AM,DCAP,VOVS,CAP1,12,3)
      CAP=CAP1*HB/0.01
      CNP=0.
      CMP=0.
      RETURN
      END
```

```
      SUBROUTINE REGONE(CP,I,J,X,Y)
      COMMON/A/ AL,XM,BETA,GAMALE,PI,R
      DIMENSION CP(9,33),X(33),Y(9)
      COMMON/B/EOFKP1(6),EOFKP2(6),EOFKP3(6),EOFKP4(6),EOFKP5(6),TPHO1(6
     1),ESKP(5),TTHET1(5)
      DATA(TPHO1(I),I=1,6)/0.,20.,40.,60.,75.,90./
      DATA(TTHET1(I),I=1,5)/0.,20.,40.,70.,90./
      DATA(EOFKP1(I),I=1,6)/0.,.3491,.6988,1.0494,1.313,1.5767/
      DATA(EOFKP2(I),I=1,6)/0.,.3483,.6921,1.029,1.2774,1.5238/
      DATA(EOFKP3(I),I=1,6)/0.,.3462,.6763,.9801,1.191,1.3931/
      DATA(EOFKP4(I),I=1,6)/0.,.3429,.6497,.8914,1.0217,1.1184/
      DATA(EOFKP5(I),I=1,6)/0.,.342,.6428,.866,.9659,1./
      XK=SQRT(1.-BETA**2/(TAN(GAMALE)**2))
      ARG=ASIN(XK)*57.29578
      CALL ELIPT1(ARG,EOFK)
      COFK=1./EOFK
      DELTA=TAN(GAMALE)*Y(I)/X(J)
      C1=SQRT(1.-DELTA**2)
      CP1=4.*AL*COFK/(TAN(GAMALE)*C1)
      CP(I,J)=CP1
      RETURN
      END
```

```
      SUBROUTINE REGTWO(CP,I,J,X,Y)
      COMMON/A/ AL,XM,BETA,GAMALF,PI,B
      DIMENSION CP(9,33),X(33),Y(9)
      COMMON/B/EOFKP1(6),EOFKP2(6),EOFKP3(6),EOFKP4(6),EOFKP5(6),TPHO1(6
     1),FSKP(5),TTHET1(5)
      DIMENSION FOF1(12),FOF2(12),FOF3(12),FOF4(12),FOF5(12),FOF6(12),FO
     1F7(12),FOF8(12),FOF9(12),FOF10(12),FOF11(12),FOF12(12),TPHO(12),TT
     2HETA(12),FSKP(12)
      DATA(TPHO1(I),I=1,6)/0.,20.,40.,60.,75.,90./
      DATA(TTHET1(I),I=1,5)/0.,20.,40.,70.,90./
      DATA(EOFKP1(I),I=1,6)/0.,.3491,.6988,1.0494,1.313,1.5767/
      DATA(EOFKP2(I),I=1,6)/0.,.3483,.6921,1.029,1.2774,1.5238/
      DATA(EOFKP3(I),I=1,6)/0.,.3462,.6763,.9801,1.191,1.3931/
      DATA(EOFKP4(I),I=1,6)/0.,.3429,.6497,.8914,1.0217,1.1184/
      DATA(EOFKP5(I),I=1,6)/0.,.342,.6428,.866,.9659,1./
      DATA(TTHETA(I),I=1,12)/0.,15.,30.,40.,50.,60.,70.,80.,85.,86.,88.,
     190./
      DATA(TPHO(I),I=1,12)/0.,20.,35.,50.,60.,70.,75.,80.,85.,87.,89.,90
     1./
      DATA(FOF1(I),I=1,12)/0.,.3491,.6109,.8727,1.0472,1.2217,1.309,1.39
     163,1.4835,1.5127,1.5475,1.5708/
      DATA(FOF2(I),I=1,12)/0.,.3495,.6133,.8792,1.0577,1.2373,1.3273,1.4
     1175,1.5078,1.5439,1.5801,1.5981/
      DATA(FOF3(I),I=1,12)/0.,.3508,.62,.8982,1.0896,1.2853,1.3846,1.484
     16,1.585,1.6253,1.6656,1.6858/
      DATA(FOF4(I),I=1,12)/0.,.352,.6264,.9173,1.1226,1.3372,1.4477,1.55
     197,1.673,1.7184,1.764,1.7868/
      DATA(FOF5(I),I=1,12)/0.,.3533,.6336,.9401,1.1643,1.4068,1.5345,1.6
     166,1.8,1.8542,1.9084,1.9356/
      DATA(FOF6(I),I=1,12)/0.,.3545,.6408,.9647,1.2126,1.4944,1.6492,1.8
     1125,1.9826,2.0519,2.1216,2.1565/
      DATA(FOF7(I),I=1,12)/0.,.3555,.6471,.9876,1.2619,1.5959,1.7927,2.0
     1119,2.2518,2.352,2.4535,2.5046/
      DATA(FOF8(I),I=1,12)/0.,.3561,.6513,1.0044,1.3014,1.6918,1.9468,2.
     12653,2.6694,2.8561,3.053,3.1534/
      DATA(FOF9(I),I=1,12)/0.,.3563,.6525,1.0091,1.3129,1.7237,2.005,2.3
     1836,2.9487,3.262,3.6328,3.8317/
      DATA(FOF10(I),I=1,12)/0.,.3563,.6526,1.0097,1.3144,1.7279,2.0129,2
     1.4015,3.0037,3.4233,3.8429,4.0528/
      DATA(FOF11(I),I=1,12)/0.,.3564,.6528,1.0104,1.3163,1.7335,2.0238,2
     1.4272,3.0945,3.7538,4.4131,4.7427/
      DATA(FOF12(I),I=1,12)/0.,.3564,.6528,1.0107,1.317,1.7354,2.0276,2.
     14362,3.1313,3.262,4.7413,9.529/
      CALL REGONE(CP,I,J,X,Y)
      CP1=CP(I,J)
      AO=BETA*.5*B/(X(J)+BETA*(Y(I)-.5*B))
      C1=1.-AO*XM
      C2=XM-1.
      C3=(C1*C2)/(2.*XM*(AO+1.))
      XLK=SQRT(C3)
      ARGU1=SQRT(XM**2-1.)/XM
      THETA=ASIN(ARGU1)*57.29578
      CALL ELIPT1(THETA,F1)
      THETA=ASIN(XLK)*57.29578
      CALL ELIPT2(THETA,RK)
```

```
      XKPRIM=SQRT(1.-XLK**2)
      THETA=ASIN(XKPRIM)*57.29578
      CALL ELIPT2(THETA,BKPRIM)
      C4=AO*(X(J)+BETA*Y(I)*XM)
      C5=BETA*.5*B*(AO*XM+1.)
      C6=SQRT(C4/C5)
      PSI=ASIN(C6)*57.29578
      CALL ELIPT1(THETA,FKPRIM)
      THETO1=PSI
      CALL INTERP(TPHO,FOF1,THETO1,FSKP(1),12,3)
      CALL INTERP(TPHO,FOF2,THETO1,FSKP(2),12,3)
      CALL INTERP(TPHO,FOF3,THETO1,FSKP(3),12,3)
      CALL INTERP(TPHO,FOF4,THETO1,FSKP(4),12,3)
      CALL INTERP(TPHO,FOF5,THETO1,FSKP(5),12,3)
      CALL INTERP(TPHO,FOF6,THETO1,FSKP(6),12,3)
      CALL INTERP(TPHO,FOF7,THETO1,FSKP(7),12,3)
      CALL INTERP(TPHO,FOF8,THETO1,FSKP(8),12,3)
      CALL INTERP(TPHO,FOF9,THETO1,FSKP(9),12,3)
      CALL INTERP(TPHO,FOF10,THETO1,FSKP(10),12,3)
      CALL INTERP(TPHO,FOF11,THETO1,FSKP(11),12,3)
      CALL INTERP(TPHO,FOF12,THETO1,FSKP(12),12,3)
      CALL INTERP(TTHETA,FSKP,THETA,FSKP1,12,3)
      CALL INTERP(TPHO1,EOFKP1,THETO1,ESKP(1),6,3)
      CALL INTERP(TPHO1,EOFKP2,THETO1,ESKP(2),6,3)
      CALL INTERP(TPHO1,EOFKP3,THETO1,ESKP(3),6,3)
      CALL INTERP(TPHO1,EOFKP4,THETO1,ESKP(4),6,3)
      CALL INTERP(TPHO1,EOFKP5,THETO1,ESKP(5),6,3)
      CALL INTERP(TTHET1,ESKP,THETA,ESKP1,5,3)
      C7=SQRT((2.*BETA*(.5*B-Y(I)))/(X(J)+BETA*Y(I)))
      C8=4.*AL/(BETA*XM**1.5*E1*PI)
      C9=C7*BK
      C10=-2.*X(J)*SQRT(XM/(X(J)**2-BETA**2*Y(I)**2*XM**2))
      C11=FSKP1/BKPRIM*(PI*.5-BK*EKPRIM)
      C12=BK*ESKP1
      CP2=C8*(C9+C10*(C11+C12))
      CP(I,J)=CP1+CP2
      RETURN
      END
```

```
      SUBROUTINE REG1(CP,I,J)
      COMMON/A/ AL,XM,BETA,GAMALF,PI,B
      DIMENSION CP(9,33)
      FACT=SQRT(1.-XM**2)
      CP(I,J)=4.*AL/(BETA*FACT)
      RETURN
      END
```

```
      SUBROUTINE REG2(CP,I,J,X,Y)
      COMMON/A/ AL,XM,BETA,GAMALE,PI,B
      DIMENSION CP(9,33),X(33),Y(9)
      DELTA=TAN(GAMALE)*Y(I)/X(J)
      C1=XM**2-DELTA**2
      C2=1.-DELTA**2
      C3=SQRT(C1/C2)
      C4=1.-2.*ASIN(C3)/PI
      FACT=SQRT(1.-XM**2)
      CP(I,J)=4.*AL/(BETA*FACT)*C4
      RETURN
      END
```

```
      SUBROUTINE REG3(CP,I,J,X,Y)
      COMMON/A/ AL,XM,BETA,GAMALF,PI,B
      DIMENSION CP(9,33),X(33),Y(9)
      Y1=Y(I)-.5*B
      X1=X(J)-.5*B*TAN(GAMALF)
      DELTA1=TAN(GAMALF)*Y1/X1
      C1=DELTA1+XM
      C2=-DELTA1*(1.+XM)
      C3=SQRT(C1/C2)
      C4=ATAN(C3)
      FACT=SQRT(1.-XM**2)
      CP3=-8.*AL/(PI*BETA*FACT)*C4
      CP1=4.*AL/(BETA*FACT)
      CP(I,J)=CP1+CP3
      RETURN
      END
```

```
      SUBROUTINE PEG4(CP,I,J,X,Y)
      COMMON/A/ AL,XM,BETA,GAMALF,PI,B
      DIMENSION CP(9,33),X(33),Y(9)
      Y1=Y(I)-.5*B
      X1=X(J)-.5*B*TAN(GAMALF)
      DELTA1=TAN(GAMALF)*Y1/X1
      C1=DELTA1+XM
      C2=-DELTA1*(1.+XM)
      C3=SQRT(C1/C2)
      C4=ATAN(C3)
      FACT=SQRT(1.-XM**2)
      CP4=-8.*AL/(PI*BETA*FACT)*C4
      DELTA=TAN(GAMALF)*Y(I)/X(J)
      C5=XM**2-DELTA**2
      C6=1.-DELTA**2
      C7=SQRT(C5/C6)
      C8=1.-2.*ASIN(C7)/PI
      CP2=4.*AL/(BETA*FACT)*C8
      CP(I,J)=CP2+CP4
      RETURN
      END
```

```
      SUBROUTINE REG5(CP,I,J,X,Y,K)
      COMMON/A/ AL,XM,BETA,GAMALF,PI,B
      DIMENSION CP(9,33),X(33),Y(9),FACTOR(33)
      C12=.5*B*BETA
      YJ=Y(I)-.5*B
      DELTA=XM
      C1=XM**2-DELTA**2
      C2=1.-DELTA**2
      C3=SQRT(C1/C2)
      C4=ASIN(C3)
      FACT=SQRT(1.-XM**2)
      SUM=0.
      DO 10 L=K,J
      IF(L.GT.K) GO TO 20
      FACTOR(L-1)=-4.*AL/(BETA*FACT)*(1.-2.*C4/PI)
   20 CONTINUE
      XE=-BETA*(.5*B-Y(I))+X(L)
      DELTA=TAN(GAMALF)*.5*B/XE
      C1=XM**2-DELTA**2
      C2=1.-DELTA**2
      C3=SQRT(C1/C2)
      C4=ASIN(C3)
      FACTOR(L)=-4.*AL/(BETA*FACT)*(1.-2.*C4/PI)
      XE=-BETA*(.5*B-Y(I))+X(L-1)
      IF(XE.LT.C12) XE=C12
      XI=X(J)-XE
      DELTAI=YJ/XI*TAN(GAMALF)
      C5=XM+DELTAI
      C6=-DELTAI*(1.+XM)
      ARG=C5/C6
      IF(ARG.LT.0.) ARG=1.E-10
      C7=SQRT(ARG)
      C8=ATAN(C7)*2./PI
      SUM=SUM+C8*(FACTOR(L)-FACTOR(L-1))
   10 CONTINUE
      CP5=SUM
      CALL REG2(CP,I,J,X,Y)
      CP2=CP(I,J)
      Y1=Y(I)-.5*B
      X1=X(J)-.5*B*TAN(GAMALF)
      DELTA1=TAN(GAMALF)*Y1/X1
      C1=DELTA1+XM
      C2=-DELTA1*(1.+XM)
      C3=SQRT(C1/C2)
      C4=ATAN(C3)
      FACT=SQRT(1.-XM**2)
      CP4=-8.*AL/(PI*BETA*FACT)*C4
      CP(I,J)=CP5+CP4+CP2
      RETURN
      END
```

```
      SUBROUTINE RK(DEOUT,DEIN,DX,NGPAT,M1)
      DIMENSION DEOUT(10),DEIN(10),DF1(10),DF2(10)
      DO 75 I=1,NGPAT
      GO TO (55,60,65,70),M1
   55 DF1(I)=DEIN(I)
      DF2(I)=DEOUT(I)*DX
      USE1=DF2(I)*.5
      GO TO 75
   60 USE1=DEOUT(I)*2.*DX
      DF2(I)=DF2(I)+USE1
      USE1=USE1*.25
      GO TO 75
   65 USE1=DEOUT(I)*2.*DX
      DF2(I)=DF2(I)+USE1
      USE1=USE1*.5
      GO TO 75
   70 USE1=DEOUT(I)*DX
      USE1=(DE2(I)+USE1)/6.
   75 DEIN(I)= DF1(I)+USE1
      RETURN
      END
```

```
      SUBROUTINE SIMP
      COMMON/GEOM/RR(6),X(30),R(30),C2,N,NSH,...,N2,XB(225), (225)
      COMMON/GE01/ RBP(225),BETA
      COMMON/CPV/ CPV(225,7),JA,JB
      COMMON/DIS2/SUM1,SUM2,SUM3,SUM4,SUM5,SUM
      COMMON/GE04/K,F,PP,RREF
      DIMENSION F1(225),G(225),G1(225)
      DO 1 I=JA,JB
      A1=CPV(I,1)+2.*(CPV(I,3)+CPV(I,5))+CPV(I,7)
      A2=4.*(CPV(I,2)+CPV(I,4)+CPV(I,6))
      F1(I)=0.17454*(A1+A2)*RB(I)
      B1=CPV(I,1)-CPV(I,7)+2.*(CPV(I,3)-CPV(I,5))*C.5
      B2=4.*(CPV(I,2)-CPV(I,6))*0.8667
      G(I)=0.17454 (B1+B2)*RB(I)
      G1(I)=G(I)*X (I)
    1 CONTINUE
      IF(JA.NE.JB)    O 2
      SUM1=0.
      SUM2=0.
      SUM3=0.
      GO TO 99
    2 JBB=JB-1
      DO 3 I=JA,JBB
    7 H=(RB(I+1)-RB(I))/6.
      X12=(XB(I+1)+XB(I))/2.
      IF((JB-JA).LT.5) GO TO 4
      J=JA+2
      CALL INTERP(XB,F1,X12,F12,JB,J)
      CALL INTERP(XB,G,X12,G12,JB,J)
      CALL INTERP(XB,G1,X12,G112,JB,J)
      GO TO 5
    4 F12=(F1(I)+F1(I+1))/2.
      G12=(G(I)+G(I+1))/2.
      G112=(G1(I)+G1(I+1))/2.
      IF(JB.GT.2) GO TO 5
      F1(3)=F1(2)
      G(3)=G(2)
      G1(2)=2./3.*G1(2)
      G1(3)=G1(2)
      G112=2./3.*G112
    5 SUM1=SUM1+H*(F1(I)+4.*F12+F1(I+1))
      H1=(XB(I+1)-XB(I))/6.
      SUM2=SUM2+H1*(G(I)+4.*G12+G(I+1))
      SUM3=SUM3+H1*(G1(I)+4.*G112+G1(I+1))
    3 CONTINUE
      SUM3=SUM3+SUM2*PP
   99 RETURN
      END
```

```
      SUBROUTINE SIMPH(CP,XH,ZPR,JI,JK,J,LK)
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,CABLW
      DIMENSION CP(70,9),ZPR(70),XH(70)
      LK=1
      E=JI
      K1=JI
      E=E-.1
      EE=E/2.
      KK=K1/2
      E1=KK
      IF(EE.GT.E1) LK=2
      DO 1 K=JI,JK
      E=K
      K1=K
      IF(LK.NE.2) GO TO 3
      E=E-1.
      K1=K-1
    3 E=E-.1
      EE=E/2.
      KK=K1/2
      E1=KK
      IF(EE.LE.E1) GO TO 53
      FHALF=CP(K,J)*ZPR(K)
      GO TO 1
   53 IF(K.GT.JI) GO TO 54
      FI=CP(JI,J)*ZPR(JI)
      F=FI
      GO TO 1
   54 FI=CP(K,J)*ZPR(K)
      DX=(XH(K)-XH(K-2))/2.
      SUM2=SUM2+DX/3.*(F+4.*FHALF+FI)
      F=FI
    1 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SING (ALGW,C)
      DIMENSION C(20),ALGW(20)
      COMMON/AERO4/RS1(10),RS2(20),S(20)
      COMMON/AERO6/QI12(20,20),QI21(20,20),PI11(10,10),PI22(10,10)
      COMMON/AERO9/N1,N2,N4
      COMMON/AERO10/SPAN,CR,CT,OMEGA,PSS
      PI=3.1415927
      LA=N1+1
      LB=N1+N2
      DO 600 JR=1,N1
      C5=0.0
      DO 700 J=1,N1
      IF(J-JR)800,700,800
  800 SJ=S(J)
      SR=S(JR)
      C1=SQRT(SR-SR*RS1(JR))
      C2=SR*RS1(JR)-SJ*RS1(J)
      C3=ALOG(ABS(C2))*SJ
      C4=SQRT(SJ-SJ*RS1(J))
      C5=C5+C2**2*C3*C4*PI11(J,JR)
  700 CONTINUE
      C7=SQRT(1.-SR/SJ*RS1(JR))
      C6=SJ**1.5   *2./3.*(ALOG(ABS(1.-C7**2))-2./3.-2.*C7**2+C7**3*ALOG
     1(ABS((1.+C7)/(1.-C7)))+ALOG(SJ))
      C8=C5/C1
      C9=C6/C1
      SUM=C9-C8
  600 ALGW(JR)=SUM
      DO 601 JR=1,N1
      C5=0.0
      DO 701 J=LA,LB
      SJ=S(J)
      SR=S(JR)
      C1=SQRT(SR+SR*RS1(JR))
      C2=SR*RS1(JR)-SJ*RS2(J)
      C3=ALOG(ABS(C2))*SJ
      C4=SQRT(SJ+SJ*RS2(J))
      C5=C5+C2**2*C3*C4*QI21(J,JR)
  701 CONTINUE
      C7=SQRT(1.+SR/SJ*RS1(JR))
      C6=SJ**1.5   *2./3.*(ALOG(ABS(1.-C7**2))-2./3.-2.*C7**2+C7**3*ALOG
     1(ABS((1.+C7)/(1.-C7)))+ALOG(SJ))
      C8=C5/C1
      C9=C6/C1
      SUM=C9-C8
  601 ALGW(JR)=(ALGW(JR)+SUM)/(4.*PI*C(JR))
      DO 602 JR=LA,LB
      C5=0.0
      DO 702 J=LA,LB
      IF(J-JR)802,702,802
  802 SJ=S(J)
      SR=S(JR)
      C1=SQRT(SR+SR*RS2(JR))
      C2=SR*RS2(JR)-SJ*RS2(J)
      C3=ALOG(ABS(C2))*SJ
```

```
      C4=SQRT(SJ+SJ*RS2(J))
      K1=J-N1
      K2=JP-N1
      C5=C5+C2**2*C3*C4*PI22(K1,K2)
  702 CONTINUE
      C7=SQRT(1.+SR/SJ*RS2(JR))
      C6=SJ**1.5   *2./3.*(ALOG(ABS(1.-C7**2))-2./3.-2.*C7**2+C7**3*ALOG
     1(ABS((1.+C7)/(1.-C7)))+ALOG(SJ))
      C8=C5/C1
      C9=C6/C1
      SUM=C9-C8
  602 ALGW(JR)=SUM
      DO 603 JR=LA,LB
      C5=0.0
      DO 703 J=1,N1
      SJ=S(J)
      SR=S(JR)
      C1=SQRT(SR-SR*RS2(JR))
      C2=SJ*RS1(J)-SR*RS2(JR)
      C3=ALOG(ABS(C2))*SJ
      C4=SQRT(SJ-SJ*RS1(J))
      C5=C5+C2**2*C3*C4*QI12(J,JR)
  703 CONTINUE
      C7=SQRT(1.-SR/SJ*RS2(JR))
      C6=SJ**1.5   *2./3.*(ALOG(ABS(1.-C7**2))-2./3.-2.*C7**2+C7**3*ALOG
     1(ABS((1.+C7)/(1.-C7)))+ALOG(SJ))
      C8=C5/C1
      C9=C6/C1
      SUM=C9-C8
  603 ALGW(JR)=(ALGW(JR)+SUM)/(4.*PI*C(JR))
      RETURN
      END
```

```
      SUBROUTINE SKINF
      COMMON/GEOM/PP(6),X(30),R(30),C2,N,NSHAP,N1,N2,XB(225),  (225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NBLUNT,NN,NNI,IPPINT,NN1A
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,NNIA
      COMMON/GEO4/ K,F,RR,RREF
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,CABLW
      COMMON/CPV/ CPV(225,7),JA,JB
      COMMON/VOL/ VOL,CAF,CNF,CMF,RN,DIA,XP,AP,VOLN,CP,CT,BW,CAFWI
      IF(NBLUNT.EQ.1) GO TO 5
      IF(NFL.EQ.2) GO TO 5
      SUM1=6.28318*RR*YINT
      SUM2=3.14159*YINT**2*(RP-YINT/3.)
      THE=ATAN(-YINT/XINT)
      SUM3=RR**2*THE/2.-RR**2*SIN(THE)/2.
      AB=ACOS((RR+XINT)/RR)
    4 SUM4=SUM3+2./3.*RR**3*(1.-SIN(AB)**3)
      GO TO 6
    5 SUM1=0.
      SUM2=0.
      SUM3=0.
      SUM4=0.
    6 CF3=0.
C     THIS SUBROUTINE CALCULATES THE AXIAL FORCE COEFFICIENT DUE TO SKIN
C     FRICTION ON THE BODY (CDF).
      PI=3.14159
      AREF=PI*RREF**2
      GAMA=1.4
      TWOTI=1.+0.9*(GAMA-1.)*(VOVS**2/2.)
      C=GAMA-1.
      A=SQRT(C*VOVS**2/(2.*TWOTI))
      B=(1.+.5*C*VOVS**2)/TWOTI-1.
      D=SQRT(B**2+4.*A**2)
      C1=(2.*A**2-B)/D
      D2=B/D
      D3=.242/(A*SQRT(TWOTI))
      D4=ASIN(C1)
      C5=ASIN(D2)
      C6=(1.+2.*.76)/2.*ALOG10(TWOTI)
      C7=D3*(D4+C5)
      PN3=RN*XB(NN)*DIA
      CALL NEWRAP(C7,PN3,C6,H,CF3)
      IF(NBLUNT.EQ.1) GO TO 1
      K=NNIA
      K1=NN1
      K2=NN2
      K3=NN3
      K4=NN4
      GO TO 2
    1 K=1
      K1=NN1
      K2=NN2
      K3=NN3
      K4=NN4
    2 JA=K
```

```
      JB=K1
      IF(JB.EQ.NN) JB=NN-1
      CALL TRAPE
      VOLN=SUM2
      IF(NN1.EQ.NN) GO TO 99
      JA=K1+1
      JB=K2
      IF(JB.EQ.NN) JB=NN-1
      CALL TRAPE
      IF(NBLUNT.EQ.2) VOLN=SUM2
      IF(NN1A.EQ.2) VOLN=SUM2
      IF(NN2.EQ.NN) GO TO 99
      JA=K2+1
      JB=K3
      IF(JB.EQ.NN) JB=NN-1
      CALL TRAPE
      IF(NN3.EQ.NN) GO TO 99
      JA=K3+1
      JB=NN-1
      CALL TRAPE
99    SB =SUM1
      VOL=SUM2
      AP=SUM3
      XP=SUM4/SUM3
      RNCRIT=1000000.
      CALL NEWRAP(C7,RNCRIT,C6,H,CFCRIT)
      XCRIT=RNCRIT/(RN*DIA)
      SCRIT=SB*XCRIT/(XB(NN)+RR)
      IF(SCRIT.GT.SB) SCRIT=SB
      CDFB=CF3*SB/AREF-CFCRIT*SCRIT/AREF+1.328*SCRIT/AREF/SQRT(RNCRIT)
      CAF=CDFB
      CNF=0.
      CMF=0.
      RETURN
      END
```

```
      SUBROUTINE SKINFW
      COMMON/VOL/ VOL,CAF,CNF,CMF,RN,DIA,XP,AP,VOLN,CR,CT,BW,CAFWI
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,NNIA
C     THIS SUBROUTINE CALCULATES THE SKIN FRICTION COEFFICIENT ON A WING.
C     THE REYNOLDS NUMBER IS BASED ON THE MEAN GEOMETRIC CHORD.
      CAFWI=0.
      IF(CR.LE.0.001) GO TO 2
      CF1=0.
      GAMA=1.4
      TWOTI=1.+.9*(GAMA-1.)*(VOVS**2/2.)
      C=GAMA-1.
      A=SQRT(C*VOVS**2/(2.*TWOTI))
      B=(1.+.5*C*VOVS**2)/TWOTI-1.
      D=SQRT(B**2+4.*A**2)
      C1=(2.*A**2-B)/D
      D2=B/D
      D3=.242/(A*SQRT(TWOTI))
      D4=ASIN(C1)
      C5=ASIN(D2)
      C6=(1.+2.*.76)/2.*ALOG10(TWOTI)
      C7=D3*(D4+C5)
      CBAR=CR-(CR-CT)/3.*(CR+2.*CT)/(CR+CT)
      RN1=RN*CBAR
      CALL NEWRAP(C7,RN1,C6,F,CF1)
      RNCRIT=500000.
      CALL NEWRAP(C7,RNCRIT,C6,F,CFCRIT)
      XCRIT=RNCRIT/RN
      SWW=2.*BW*(CR+CT)
      SCRIT=SWW*XCRIT/CBAR
      IF(SCRIT.GT.SWW) SCRIT=SWW
    1 CAFWI= CF1*SWW-CFCRIT*SCRIT+1.328*SCRIT/SQRT(RNCRIT)
    2 RETURN
      END
```

```
      SUBROUTINE SUBCNA(RF,CRF,CTF,GAMAF,SF,ALP,XLEF,CNAF,XCPF,VOVS,L,M,
     1N)
      REAL MACH
      DIMENSION AP(50,50),RVEC(50,1)
      COMMON/AERO9/N1,N2,N4
      COMMON /AERO10/SPAN,CP,CT,OMEGA,PSS
      COMMON/AERO11/SAREA,ALPHAWB,CLT,BETAM
      COMMON/ANAME/ROLL,PITCH,MACH,ALPHA,RC,XCG,DIHED
      PSS=1.
      ROLL=0.
      PITCH=0.
      RC=1.
      XCG=0.
      DIHED=0.
      SPAN=RF
      CP=CRF
      CT=CTF
      OMEGA=GAMAF
      SAREA=SF
      ALPHA=ALP
      MACH=VOVS
      N1=L
      N2=M
      N4=N
      NSQ=(N1+N2)*N4
      CALL GUIDED (AP,RVEC,NSQ,CNAF,XLEF,XCPF)
      RETURN
      END
```

```
      SUBROUTINE SUBTRN(CR,CT,B,GAMA,TOVC,CNA ,CNA1P4,TCNATR,    ,VOVS1
     1)
      DIMENSION TCNATR(5),TMTR(5)
      DIMENSION TTOVC(13),TAR(5),TMFBO(13,5),GCOV2(9),TFBMO(5),TFBMG(9,5
     1),TOT(9),TAR2(6),TCLAR(9,6),TOT2(11),TAOVC(11,6),TOT4(9),TBOVC(9)
      DATA(TTOVC(I),I=1,13)/0.,.03,.0425,.064,.08,.098,.11,.12,.132,.135
     1,.14,.145,.16/
      DATA(TAR(I),I=1,5)/1.,2.,3.,4.,6./
      DATA((TMFBO(I,J),I=1,13),J=1,5)/1.,1.,1.,1.,1.,1.,1.,1.,1.,.95,.91
     1,.87,.825,1.,1.,1.,1.,1.,1.,.925,.89,.865,.855,.845,.835,.82,1.,1.
     2,1.,1.,.94,.89,.875,.86,.84,.835,.83,.8225,.815,1.,1.,.95,.895,.87
     3,.845,.83,.825,.815,.81,.805,.795,.785,1.,.93,.90,.87,.84,.82,.81,
     4.80,.79,.785,.78,.7775,.775/
      DATA(GCOV2(I),I=1,9)/0.,10.,20.,30.,40.,50.,60.,70.,80./
      DATA(TFBMO(I),I=1,5)/.8,.85,.9,.95,1./
      DATA((TFBMG(I,J),I=1,9),J=1,5)/.8,.81,.8225,.84,.87,.89,.92,.945,.
     197,.85,.855,.865,.8775,.9,.92,.94,.96,.975,.9,.905,.91,.92,.93,.94
     25,.96,.975,.98,.95,.95,.96,.965,.97,.975,.98,.985,.99,1.,1.,1.,1.,
     31.,1.,1.,1.,1./
      DATA(TOT(I),I=1,9)/.017,.0325,.04,.05,.06,.07,.12,.153,.16/
      DATA(TAR2(I),I=1,6)/1.,2.,3.,4.,6.,8./
      DATA((TCLAR(I,J),I=1,9),J=1,6)/1.09,1.075,1.06,1.04,1.01,.98,.88,.
     18,.8,1.07,1.1,1.1,1.08,1.05,1.02,.89,.8,.8,.98,1.07,1.08,1.08,1.07
     2,1.04,.9,.8,.8,.89,.98,1.02,1.06,1.075,1.07,.9,.8,.8,1.15,1.15,1.1
     35,1.15,1.15,1.1,.92,.8,.8,1.160,1.160,1.160,1.160,1.160,1.16,.94,.
     48,.8/
      DATA(TOT2(I),I=1,11)/0.,.06,.0725,.08,.089,.10,.12,.1525,.155,.157
     15,.16/
      DATA((TAOVC(I,J),I=1,11),J=1,6)/-.14,-.14,-.14,-.14,-.14,-.14,-.14
     1,0.,0.,0.,0.,-.07,-.07,-.07,-.07,-.07,0.,.3,.85,.9,.95,.975,.06,.0
     26,.06,.065,.1,.225,.49,.92,.975,1.,1.,.07,.07,.1,.14,.225,.35,.575
     3,.95,.975,1.,1.,.15,.15,.20,.28,.365,.475,.66,.975,1.,1.,1.,.4,.4,
     4.4,.4,.46,.55,.725,1.,1.,1.,1./
      DATA(TOT4(I),I=1,9)/0.,.01,.02,.04,.06,.07,.08,.12,.16/
      DATA(TBOVC(I),I=1,9)/-.03,-.025,0.,.075,.125,.15,.15,.15,.15/
      AR=2.*B/(CR+CT)
      GAM1=GAMA/57.3
      XOVC=TOVC
      TANCO2=(.5*B*TAN(GAM1)-.5*CR+.5*CT)/(.5*B)
      AR1=AR
      AR2=AR
      CBAR=CR-(CR-CT)*(CR+2.*CT)/(3.*(CR+CT))
      IF(AR1.LE.1.) AR1=1.00011
      IF(AR1.GE.6.) AR1=5.99988
      IF(AR2.LE.1.) AR2=1.00011
      IF(AR2.GT.8.) AR2=7.99988
      CALL AINTER(TAR,TTOVC,TMFBO,XMFB,TOVC,AR1,13,5)
      CALL AINTER(TFBMO,GCOV2,TFBMG,FBMN,GAMA,XMFB,9,5)
      BETAFB=SQRT(ABS(1.-FBMN**2))
      XKAPPA=.9
      FACT=2.+SQRT(AR**2/XKAPPA**2*(BETAFB**2+TA  O2**2)+4.)
      CNAFBT=6.283185*AR/FACT
      IF(AR2-4.) 1,1,2
    2 IF(AR2-6.) 3,3,4
    3 CONTINUE
```

```
      IF(XOVC.LT..06) XOVC=.06
      GO TO 1
    4 CONTINUE
      IF(XOVC.LT..08) XOVC=.08
    1 CONTINUE
      CALL ATNTFR(TAP2,TOT,TCLAR,CLAR,XOVC,  .  ,6)
      CLAFR=CLAR*CNAFRT
      IF(AR2-2.) 5,6,6
    5 CONTINUE
      IF(XOVC.GT..08) XOVC=.08
    6 CALL ATNTFF(TAR2,TOT2,TAOVC,AOVC,XOVC,AR2,11,6)
      XMA=FRMN+.37
      CLAA=(1.-AOVC)*CLAFR
      IF(TOVC.GT..16) TOVC=.16
      CALL FOINT(TOT4,TBOVC,TOVC,BOVC,9)
      XMB=FRMN+.16
      CLAB=(1.-BOVC)*CLAFR
      TCNATR(1)=CNAR4
      TCNATR(2)=CLAFR
      TCNATR(3)=CLAA
      TCNATR(4)=CLAB
      TCNATR(5)=CNA1R4
      TMTR(1)=.8
      TMTR(2)=FRMN
      TMTR(3)=XMA
      TMTR(4)=XMB
      TMTR(5)=VOVS1
      RETURN
      END
```

```
      SUBROUTINE SUBXCP(B,BETA,DISXCP,XCP)
      DIMENSION DISXCP(11),XCP(4),A(4,4),XCP1([illegible]),Y1(11)
      COMMON/7/XLE(4),XTE(4),Y(4),GAMA,XCPF
      DO 1 I=1,4
      C=(XTE(I)-XLE(I))*BETA
      XCP1(I,1)=XLE(I)*BETA+XCP(I)*C
      Y(I)=Y(I)*.5*B
    1 CONTINUE
      DY=B/20.
      DO 10 L=1,4
      DO 10 K=1,4
      IF(K-1) 11,11,12
   11 A(L,K)=1.
      GO TO 10
   12 KK=K-1
      A(L,K)=Y(L)**KK
   10 CONTINUE
      CALL MINVR(A,4,XCP1,1,DETERM,IERR)
      XCPRT=XCP1(1,1)
      SUM=0.
      DO 8 I=1,11
      IF(I-1) 18,18,19
   18 DISXCP(1)=XCPRT
      Y1(1)=0.
      GO TO 8
   19 SUM=SUM+DY
      Y1(I)=SUM
      DISXCP(I)=XCP1(1,1)+XCP1(2,1)*Y1(I)+XCP1(3,1)*Y1(I)**2+XCP1(4,1)*Y
     11(I)**3
    8 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SUPCNA(CP,CT,SPAN,VOVS,ALPHA,IPRINT,GAMA,XLE,   F,CREF,
     1CNAF,XCPF,K)
      COMMON/A/ AL,XM,BETA,GAMALE,PI,B
      DIMENSION CP(9,33),X(33),Y(9)
      DIMENSION XLE(9),XTE(9),CHORD(9),CCN(9)
      DIMENSION CN(9),CM(9),CN1(9),CM1(9),CCM1(9)
      N=K
      CNAF=0.
      XCPF=C.
      PI=3.14159
      DC 1 I=1,9
  900 FORMAT(10X,3F10.4)
  901 FORMAT(13X,7H(Y/B/2),7X,3HCNS,7X,3HCMS)
      DC 1 J=1,33
    1 CP(I,J)=0.
      B=SPAN
      GAMALE=GAMA/57.29578
      TANGAM=TAN(GAMALE)
      GAMATE=ATAN((CT-CR+.5*B*TANGAM)/(.5*B))
      XMNTE=VOVS*COS(GAMATE)+.00001
      IF(XMNTE-1.) 503,504,504
  503 VOVS=1./COS(GAMATE)+.00001
      PRINT 505
  505 FORMAT(1X,88HSUPSONIC TRAILING EDGE ENCOUNTERED.MACH NUMBER INCREA
     1SED SO THAT TRAILING EDGE IS SONIC.)
  504 CONTINUE
      BETA=SQRT(ABS(VOVS**2-1.))
      XMNLE=VOVS*COS(GAMALE)
      AL=ALPHA/57.29578
      XMU=ASIN(1./VOVS)
      XM=TANGAM/BETA
      YM1=CR/(BETA-TANGAM-2./B*CT+2./B*CR)
      YM2=(.5*B*TANGAM-CR+BETA*.5*B)/(TANGAM+2./B*CT-2./B*CR+BETA)
      YM3=(BETA*B-CR)/(TANGAM+2./B*CT-2./B*CR+BETA)
    3 CONTINUE
      SUM=C.
      DY=B/16.
      DO 115 I=1,9
      IF(I.EQ.1.OR.I.EQ.9) GO TO 12
      GO TO 13
   12 CONTINUE
      IF(I.EQ.1) Y(1)=.00001
      IF(I.EQ.9) Y(9)=.5*B-.00001
      GO TO 14
   13 SUM=SUM+DY
      Y(I)=SUM
   14 XLE(I)=Y(I)*TANGAM
      XTE(I)=2.*Y(I)/B*(.5*B*TANGAM+CT-CR)+CR
      CHORD(I)=XTE(I)-XLE(I)
      DX=(XTE(I)-XLE(I))/32.
      XM1=Y(I)*BETA
      XM2=-BETA*(Y(I)-.5*B)+.5*B*TANGAM
      XM3=-BETA*(Y(I)-.5*B)+.5*B*BETA
      IF(IPRINT-1) 91,91,92
   91 IF(K-1) 94,94,93
```

```
   93 CONTINUE
      PRINT 95,VOVS,CHORD(I)
   95 FORMAT(//,46X,*LIFTING PRESSURE COEFFICIENTS ON WING AT M=*,F5.3,/
     1,60X,*LOCAL CHORD=*,F6.4,*FT.*,//,40X,*Y/(B/2)*,23X,*X/C*,20X,*DEL
     2CP*,//)
      GO TO 92
   94 CONTINUE
      PRINT 96,VOVS,CHORD(I)
   96 FORMAT(//,46X,*LIFTING PRESSURE COEFFICIENTS ON CANARD AT M=*,F5.3
     1,/,60X,*LOCAL CHORD=*,F6.4,*FT.*,//,40X,*Y/(B/2)*,23X,*X/C*,20X,*D
     2ELCP*,//)
   92 CONTINUE
      SUM1=0.
      L=0
      DO 115 J=1,33
      IF(J-1) 16,16,17
   16 SUM1=.0000001*CHORD(I)
      FACTOR=SUM1
      GO TO 18
   17 SUM1=SUM1+DX
   18 X(J)=SUM1+Y(I)*TANGAM
      IF(J.EQ.33) X(J)=X(J)-FACTOR
C     DETERMINE IF THE LEADING EDGE IS SUPERSONIC OR SUBSONIC
      IF(1.-XMNLE) 5,5,6
    5 CONTINUE
C     SUPERSONIC LEADING EDGE
C     DETERMINE IF THERE ARE FOUR OR FIVE REGIONS
      TESANG=ATAN((.5*B*TANGAM+CT)/(.5*B))
      XMUCOM=1.5707963268-XMU
      IF(TESANG-XMUCOM) 7,7,8
    7 CONTINUE
C     FOUR REGIONS OR LESS
      IF(X(J).LE.XM1.AND.X(J).LE.XM2) CALL REG1(CP,I,J)
      IF(X(J).GE.XM1.AND.X(J).LE.XM2) CALL REG2(CP,I,J,X,Y)
      IF(X(J).GE.XM1.AND.X(J).GE.XM2) CALL REG4(CP,I,J,X,Y)
      IF(X(J).LE.XM1.AND.X(J).GE.XM2) CALL REG3(CP,I,J,X,Y)
      GO TO 15
    8 CONTINUE
C     FIVE REGIONS
      IF(X(J).LE.XM1.AND.X(J).LE.XM2) CALL REG1(CP,I,J)
      IF(X(J).GE.XM1.AND.X(J).LE.XM2) CALL REG2(CP,I,J,X,Y)
      IF(X(J).GE.XM2.AND.X(J).LE.XM1) CALL REG3(CP,I,J,X,Y)
      IF(X(J).GE.XM1.AND.X(J).GE.XM2.AND.X(J).LE.XM3) CALL REG4(CP,I,J,X
     1,Y)
      IF(X(J).LT.XM3) GO TO 15
      IF(X(J).GE.XM3) L=L+1
      IF(L.EQ.1) M=J
      CALL REG5(CP,I,J,X,Y,M)
      GO TO 15
C     SUBSONIC LEADING EDGES
    6 CONTINUE
      IF(J.NE.3) GO TO 102
      SUM2=0.
      SUM3=0.
      X(1)=.0000001*CHORD(I)+YLE(I)
```

```
      X(2)=.00000015*CHORD(I)+XLE(I)
      X(3)=.0000004*CHORD(I)+XLE(I)
      X(4)=.0000007*CHORD(I)+XLE(I)
      X(5)=.000001*CHORD(I)+XLE(I)
      X(6)=.000004*CHORD(I)+XLE(I)
      X(7)=.00001*CHORD(I)+XLE(I)
      X(8)=.00005*CHORD(I)+XLE(I)
      X(9)=.0001*CHORD(I)+XLE(I)
      X(10)=.0005*CHORD(I)+XLE(I)
      X(11)=.001*CHORD(I)+XLE(I)
      X(12)=.005*CHORD(I)+XLE(I)
      X(13)=.01*CHORD(I)+XLE(I)
      X(14)=.015*CHORD(I)+XLE(I)
      X(15)=.02*CHORD(I)+XLE(I)
      X(16)=.025*CHORD(I)+XLE(I)
      X(17)=.03*CHORD(I)+XLE(I)
      X(18)=.035*CHORD(I)+XLE(I)
      X(19)=.04*CHORD(I)+XLE(I)
      X(20)=.045*CHORD(I)+XLE(I)
      X(21)=.05*CHORD(I)+XLE(I)
      X(22)=.055*CHORD(I)+XLE(I)
      X(23)=.06*CHORD(I)+XLE(I)
      X(24)=.0625*CHORD(I)+XLE(I)
      DO 10 K=2,24
      DXX=X(K)-X(K-1)
      IF(X(K).GE.XM1.AND.X(K).LE.XM2) CALL REGONE(CP,I,K,X,Y)
      IF(X(K).GE.XM2) CALL REGTWO(CP,I,K,X,Y)
      SUM2=SUM2+(CP(I,K)+CP(I,K-1))*DXX*.5
      C1=(CP(I,K)+CP(I,K-1))*DXX*.5
      C2=X(K-1)
      C3=DXX/3.
      C4=CP(I,K-1)+2.*CP(I,K)
      C5=CP(I,K-1)+CP(I,K)
      SUM3=SUM3+C1*(C2+C3*C4/C5)
   10 CONTINUE
      K=N
      SUM2=SUM2+CP(I,1)*(X(1)-XLE(I))
      SUM3=SUM3+CP(I,1)*(X(1)-XLE(I))*(XLE(I)+(X(1)-XLE(I))*.5)
      CN(I)=SUM2/CHORD(I)
      CM(I)=-SUM3/(CHORD(I)*DREF)
      X(2)=X(1)+DX
      X(3)=X(2)+DX
  102 CONTINUE
      IF(X(J).GE.XM1.AND.X(J).LE.XM2) CALL REGONE(CP,I,J,X,Y)
      IF(X(J).GE.XM2) CALL REGTWO(CP,I,J,X,Y)
   15 CONTINUE
      IF(I.EQ.9.AND.J.EQ.1) CP(I,J)=0.
      IF(IPRINT-1) 220,220,115
  220 CONTINUE
      YN=Y(I)/(.5*B)
      XN=(X(J)-XLE(I))/CHORD(I)
      PRINT 222,YN,XN,CP(I,J)
  222 FORMAT(41X,F5.3,20X,F7.4,18X,F6.3)
  115 CONTINUE
      IF(1.-XMNLE) 25,25,26
```

```
   2  SUM3=0.
      SUM5=0.
      DO 50 J=1,9
      SUM2=0.
      SUM4=0.
      XLE(J)=Y(J)*TANGAM
      XTE(J)=2.*Y(J)/B*(.5*B*TANGAM+CT-CR)+CR
      C=(XTE(J)-XLE(J))
      DX=C/32.
      DO 31 I=1,33
      IF(I-1) 80,80,81
   80 SUM=.0000001*C
      GO TO 82
   81 SUM=SUM+DX
   82 X(I)=SUM+Y(J)*TANGAM
      E=I
      EE=E/2.-.1
      K1=I
      KK=K1/2
      E1=KK
      IF(EE.GE.E1) GO TO 32
      FHALF=CP(J,I)
      FHAL=CP(J,I)*X(I)
      GO TO 31
   32 IF(I.GT.1) GO TO 33
      FI=CP(J,1)
      FII=CP(J,1)*X(1)
      F=FI
      FO=FII
      GO TO 31
   33 FI=CP(J,I)
      FII=CP(J,I)*X(I)
      SUM4=SUM4+DX/3.*(FO+4.*FHAL+FII)
      SUM2=SUM2+DX/3.*(F+4.*FHALF+FI)
      F=FI
      FO=FII
   31 CONTINUE
      CCN(J)=SUM2
      CNS=SUM2/C
      CMS=SUM4/(C*DREF)
      IF(IPRINT-1) 500,500,550
  500 CONTINUE
      IF(J.EQ.1) PRINT 901
      YB02=Y(J)/(.5*B)
      PRINT 900,YB02,CNS,CMS
  550 CONTINUE
      XCPS=CMS/CNS
C     TOTAL LIFT,PITCHING MOMENT,AND CENTER OF PRESSURE
      F2=J
      F2=F2-.1
      F3=F2/2.
      JJ=J/2
      F4=JJ
      IF(F3.GE.F4) GO TO 34
      FHALFY=SUM2
```

```
      FHALY=SUM4
      GO TO 50
   34 IF(J.GT.1) GO TO 36
      FIIY=SUM4
      FIY=SUM2
      FY=FIY
      FOY=FIIY
      GO TO 50
   36 FIY=SUM2
      FIIY=SUM4
      SUM3=SUM3+DY/3.*(FY+4.*FHALFY+FIY)
      SUM5=SUM5+DY/3.*(FOY+4.*FHALY+FIIY)
      FY=FIY
      FOY=FIIY
   50 CONTINUE
      CNWING=2./AREF*SUM3
      CMWING=-2.*SUM5/AREF
      XCPW=-CMWING/CNWING+XLF
      GO TO 100
   26 CONTINUE
      DO 60 I=1,9
      DX=CHORD(I)/32.
      X(1)=XLE(I)
      DO 103 J=2,33
      X(J)=X(J-1)+DX
  103 CONTINUE
      F1=4.*(CP(I,4)+CP(I,6)+CP(I,8)+CP(I,10)+CP(I,12)+CP(I,14)+CP(I,16)
     1+CP(I,18)+CP(I,20)+CP(I,22)+CP(I,24)+CP(I,26)+CP(I,28)+CP(I,30)+CP
     2(I,32))
      F2=CP(I,3)+CP(I,33)+2.*(CP(I,5)+CP(I,7)+CP(I,9)+CP(I,11)+CP(I,13)+
     1CP(I,15)+CP(I,17)+CP(I,19)+CP(I,21)+CP(I,23)+CP(I,25)+CP(I,27)+CP(
     2I,29)+CP(I,31))
      CN1(I)=CN(I)+DX/3.*(F1+F2)/CHORD(I)
      CCN(I)=CN1(I)*CHORD(I)
      G1=4.*(X(4)*CP(I,4)+X(6)*CP(I,6)+X(8)*CP(I,8)+X(10)*CP(I,10)+X(12)
     1*CP(I,12)+X(14)*CP(I,14)+X(16)*CP(I,16)+X(18)*CP(I,18)+X(20)*CP(I,
     220)+X(22)*CP(I,22)+X(24)*CP(I,24)+X(26)*CP(I,26)+X(28)*CP(I,28)+X(
     330)*CP(I,30)+X(32)*CP(I,32))
      G2=X(3)*CP(I,3)+X(33)*CP(I,33)+2.*(X(5)*CP(I,5)+X(7)*CP(I,7)+X(9)*
     1CP(I,9)+X(11)*CP(I,11)+X(13)*CP(I,13)+X(15)*CP(I,15)+X(17)*CP(I,17
     2)+X(19)*CP(I,19)+X(21)*CP(I,21)+X(23)*CP(I,23)+X(25)*CP(I,25)+X(27
     3)*CP(I,27)+X(29)*CP(I,29)+X(31)*CP(I,31))
      CM1(I)=CM(I)-DX/3.*(G1+G2)/(CHORD(I)*DREF)
      CCM1(I)=CM1(I)*CHORD(I)*DREF
      IF(IPRINT-1) 600,600,650
  600 CONTINUE
      IF(I.EQ.1) PRINT 901
      YBO2=Y(I)/(.5*B)
      PRINT 900,YBO2,CN1(I),CM1(I)
  650 CONTINUE
   60 CONTINUE
      CNWING=DY/3./AREF*(CCN(1)+4.*(CCN(2)+CCN(4)+CCN(6)+CCN(8))+2.*(CCN
     1(3)+CCN(5)+CCN(7))+CCN(9))*2.
      CMWING=2.*DY/(3.*AREF)*(CCM1(1)+4.*(CCM1(2)+CCM1(4)+CCM1(6)+CCM1(8
     1))+2.*(CCM1(3)+CCM1(5)+CCM1(7))+CCM1(9))
```

```
      XCPW=XLE-CMWING/CNWING
      YCP=(CON(1)*Y(1)+CON(2)*Y(2)+CON(3)*Y(3)+CON(4)*Y(4)+CON(5)*Y(5)+C
     1ON(6)*Y(6)+CON(7)*Y(7)+CON(8)*Y(8)+CON(9)*Y(9))/CNWING
  100 CONTINUE
      CNAF=CNWING/AL
      XCPF=XCPW/DREF
      RETURN
      END
```

```
      SUBROUTINE TRANS
      COMMON/GEOM/PP(6),X(30),R(30),C2,N,NSH ,N1,N2,XB(225), (225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NBLUNT, ,NNI,IPRINT,NN1A
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,NNIA
      COMMON/GEO4/K,F,FR,RREF
      COMMON/CPV/ CPV(225,7),JA,JB
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,CABLW
      COMMON/LENG/BL,ANL,ALA
      COMMON/WAVE/CABL,CNBL,CMBL,CAW,CNW,CMW
      DIMENSION AM(10),CA15(10),CA2(10),CA25(10),CA3(10),CA4(10)
      DATA(AM(I),I=1,8)/.85,.9,.95,1.,1.05,1.1,1.15,1.2/
      DATA(CA15(I),I=1,8)/.01,.072,.13,.177,.215,.247,.277,.3/
      DATA(CA2(I),I=1,8)/0.,.036,.073,.107,.14,.169,.191,.205/
      DATA(CA25(I),I=1,8)/0.,.01,.04,.07,.098,.122,.138,.143/
      DATA(CA3(I),I=1,8)/0.,0.,.024,.048,.073,.092,.102,.097/
      DATA(CA4(I),I=1,8)/0.,0.,.01,.032,.047,.055,.055,.04/
      CPO=0.
      IF(RBP(NN).LT.-0.0001) GO TO 87
      GO TO 88
   87 VOV=VOVS-.0498
      IF(VOV.LT.1.) GO TO 89
      AREF=3.14159*RREF**2
      IF(NSHAPE.LT.4) GO TO 88
      IF(NN1A.EQ.2) GO TO 1
      IF(NBLUNT.EQ.2) GO TO 1
      J=NN2+1
      GO TO 2
    1 J=NN3+1
    2 DO 10 L=J,NN
      XX=XB(L)-XB(J)
      DELTA=ATAN(1./(2.*ANL))
      IF(RBP(J-3).LT.RBP(1)) DELTA=ATAN(.2/ANL)
      GAMA=1.4
      C1=1.+GAMA
      C0=SQRT(C1)
      C3=VOV **2
      C4=1.-C3
      C5=C4/(C1*C3)
      C6=3.*DELTA/(2.*C0)
      C7=25.*C1*VOV **(2./3.)
      C8=.5*C4/(C1*C3)
      C9=1.25*C5**2
      C10=2.*C5/(VOV **(2./3.))*C6**(2./3.)
      C11=(C6/VOV )**(4./3.)
      CSQ=C7*(C8+(C9+C10+C11)**(.5))
      C=SQRT(CSQ)
      Y=2.*ALA  +2.*XX
      CP1      =.4*(Y-C)/SQRT(C1*VOV **(2./3.))*(.C4*(Y-C)**2/(C1*VOV **
     1(2./3.))-C4/(C1*C3))**.5
      IF(Y.GT.C) CP1=C.
      DELTA=-RBP(L)
      GAMA=1.4
      C1=1.+GAMA
      C0=SQRT(C1)
```

```
      C3=VOV **2
      C4=1.-C3
      C5=C4/(C1*C3)
      C6=3.*DELTA/(2.*C0)
      C7=25.*C1*VOV **(2./3.)
      C8=.5*C4/(C1*C3)
      C9=1.25*C5**2
      C10=2.*C5/(VOV **(2./3.))*C6**(2./3.)
      C11=(C6/VOV )**(4./3.)
      CSQ=C7*(C8+(C9+C10+C11)**(.5))
      C=SQRT(CSQ)
      Y=XX*2.
      CPV(L, 1)=.4*(Y-C)/SQRT(C1*VOV **(2./3.))*(.04*(Y-C)**2/(C1*VOV **
     1(2./3.))-C4/(C1*C3))**.5-DELTA**2+CP1
      IF(Y.GT.C) CPV(L,1)=CP1
   15 DO 10 K1=1,7
      CPV(L,K1)=CPV(L,1)
   10 CONTINUE
      JA=J
      JB=NN
      SUM1=0.
      SUM2=0.
      SUM3=0.
      CALL SIMP
      CBO=2.*SUM1/AREF
      VO=VOV-1.
      IF(VO.LE.0.06) CB1=CBO
      V1=VOVS
   89 CONTINUE
      IF(VOVS.GT.0.95) GO TO 90
      CBO=0.
      GO TO 88
   90 CBO=CB1*(VOVS-.95)/ (V1-.95)
   88 CONTINUE
      CALL INTERP(AM,CA15,VOVS,A0,8,3)
      CALL INTERP(AM,CA2 ,VOVS,A1,8,3)
      CALL INTERP(AM,CA25,VOVS,A2,8,3)
      CALL INTERP(AM,CA3 ,VOVS,A3,8,3)
      CALL INTERP(AM,CA4 ,VOVS,A4,8,3)
      IF(ANL.LE.4.) GO TO 16
      CAN=A4*(1.-.2*(ANL-4.))
      GO TO 17
   16 CALL INTERS(ANL,1.5,2.,2.5,3.,4.,A0,A1,A2,A3,A4,CAN)
   17 CAW=CAN+CBO
   99 RETURN
      END
```

```
      SUBROUTINE TRAPE
      COMMON/GEOM/PP(6),X(30),P(30),C2,N,NSHA...,N2,XB(225),...(225)
      COMMON/GEO1/ RBP(225),BETA
      COMMON/CPV/ CPV(225,7),JA,JB
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,S...,CABLW
C     THIS SUBROUTINE INTEGRATES THE SURFACE AREA,PLANFORM ARE... ...
C    VOLUME BY TRAPEZOIDAL RULE.
      PI=3.14159
      IF(JB.NE.1) GO TO 2
      SUM1=PI*RB(2)*SQRT(RB(2)**2+XB(2)**2)
      SUM2=PI/3.*RB(2)**2*XB(2)
      SUM3=.5*RB(2)*XB(2)
      SUM4=SUM3*2./3.*XB(2)
      GO TO 99
    2 DO 1 I=JA,JB
      DX=XB(I+1)-XB(I)
      SUM1=SUM1+PI*DX*(RB(I)*SQRT(1.+RBP(I)**2)+RB(I+1)*SQRT(1.+RBP(I+1
     1)**2))
      SUM2=SUM2+PI/2.*DX*(RB(I)**2+RB(I+1)**2)
      SUM3=SUM3+DX*(RB(I+1)+RB(I))
      SUM4=SUM4+DX*(XB(I+1)*RB(I+1)+XB(I)*RB(I))
    1 CONTINUE
   99 RETURN
      END
```

```
      SUBROUTINE TRNCNA(CP,CT,B,GAMA,TOVC,V    , NA,XCP,I,K,SF,  ,XLF,N1,
     1N2,N4)
      DIMENSION TCNAW(5),TMTRW(5),TCNAT(5),    (5)
      IF(I-1) 1,1,2
    1 IF(K-1)3,4,4
    3 CALL SUBCNA(B,CP,CT,GAMA,SF,AL,XLE,CNAWP8,XCPWP8,.8,N1,  ,N4)
      VOVS1=1.2
      CALL SUPCNA(CP,CT,B,VOVS1,AL,2,GAMA,XLE,SF,1.,CNAW14,XC   14,1)
      CALL SUBTRN(CP,CT,B,GAMA,TOVC,CNAWP8,CNAW14,TCNAW,TMTRW,VOVS1)
    4 CALL FOINT(TMTRW,TCNAW,VOVS,CNA,5)
      C=XCPW14-XCPWP8
      XCPP8=XCPWP8
      A=VOVS1-.8
      GO TO 10
    2 IF(K-1)5,6,6
    5 CALL SUBCNA(B,CP,CT,GAMA,SF,AL,XLE,CNATP8,XCPTP8,.8,N1,N2,N4)
      VOVS1=1.2
      CALL SUPCNA(CP,CT,B,VOVS1,AL,2,GAMA,XLE,SF,1.,CNAT14,XCPT14,2)
      CALL SUBTRN(CP,CT,B,GAMA,TOVC,CNATP8,CNAT14,TCNAT,TMTRT,VOVS1)
    6 CALL FOINT(TMTRT,TCNAT,VOVS,CNA,5)
      C=XCPT14-XCPTP8
      XCPP8=XCPTP8
      A=VOVS1-.8
   10 CONTINUE
      B1=VOVS-.8
      D=C*B1/A
      XCP=XCPP8+D
      RETURN
      END
```

```
      SUBROUTINE WAVE
      COMMON/WAVE/CABL,CNBL,CMBL,CAW,CNW,CMW
      COMMON/GEOM/PP(6),X(30),R(30),C2,N,NSHA...,.1,N2,XB(225),...225)
      COMMON/GE01/ RBP(225),BETA
      COMMON/GE02/NN1,NN2,NN3,NN4,NFL,NBLUNT,..,NNI,IPPINT,NN1.
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,CABLW
      COMMON/CPV/ CPV(225,7),JA,JB
      COMMON/GE04/K,F,PR,RREF
      COMMON/GE03/VOVS,AL,XM,YM,XINT,NNIA
      DIMENSION XN(6)
      CA2=0.
      CA3=0.
      CA4=0.
      CN2=0.
      CN3=0.
      CN4=0.
      CM2=0.
      CM3=0.
      CM4=0.
      SUM1=0.
      SUM2=0.
      SUM3=0.
      AREF=3.14159*RREF**2
      IF(NBLUNT.EQ.1) GO TO 1
      K=NNI
      K1=NN1
      K2=NN2
      K3=NN3
      K4=NN4
      GO TO 2
    1 K=1
      K1=NN1
      K2=NN2
      K3=NN3
      K4=NN4
      CABL=0.
      CNBL=0.
      CMBL=0.
    2 JA=K
      JB=K1
      CALL SIMP
      CA1= 2.*SUM1/AREF
      CN1=-2.*SUM2/AREF
      CM1= 2.*SUM3/(AREF*2.*RREF)
      SUM1=0.
      SUM2=0.
      SUM3=0.
      IF(NN1.EQ.NN ) GO TO 99
      JA=K1+1
      JB=K2
      CALL SIMP
      CA2= 2.*SUM1/AREF
      CN2=-2.*SUM2/AREF
      CM2= 2.*SUM3/(AREF*2.*RREF)
      SUM1=0.
```

```
      SUM2=0.
      SUM3=0.
      IF(NN2.EQ.NN ) GO TO 99
      JA=K2+1
      JB=K3
      CALL SIMP
      CA3= 2.*SUM1/AREF
      CN3=-2.*SUM2/AREF
      CM3= 2.*SUM3/(AREF*2.*RREF)
      SUM1=0.
      SUM2=0.
      SUM3=0.
      IF(NN3.EQ.NN ) GO TO 99
      JA=K3+1
      JB=K4
      CALL SIMP
      CA4= 2.*SUM1/AREF
      CN4=-2.*SUM2/AREF
      CM4= 2.*SUM3/(AREF*2.*RREF)
   99 CAW= CABL+CA1+CA2+CA3+CA4
      CNW= CNBL+CN1+CN2+CN3+CN4
      CMW=CMBL+CM1+CM2+CM3+CM4
      RETURN
      END
```

```
      SUBROUTINE WING(GA,CP,CT,B,CR1,CR2,RR,[illegible],TR,TT,MHC,IW)
      COMMON/GEO3/VOVS,AL,XM,YM,XINT,YINT,[illegible]
      COMMON/GEO2/NN1,NN2,NN3,NN4,NFL,NBLUNT,[illegible],NNI,IPRINT,[illegible]
      COMMON/DIS2/ SUM1,SUM2,SUM3,SUM4,SUM5,[illegible],CARLW
      COMMON/CPWING/ TGA(70),ETA(70),AMU,XP,[illegible](70),YP,DZDX(70),[illegible](70),IL
      COMMON/GEO1/PBP(225),BETA
      DIMENSION GA(4),Y(10),X(70),CP(70,9),ZPP(70),CPN(40),TH(40),
     1ZO(40),XW(70)
      M=9
      AMU = ASIN(1./VOVS)
      RAD=57.29583
      CARLW=0.
      SUM3=0.
      IF(CP .LE.0.00001) GO TO 97
      SUM6=B
      DO 2 J=1,4
      IF(GA(J).LE.1.) GA(J)=1.
      TGA(J)= TAN(GA (J)/RAD)
      ETA(J)=TGA(J)/BETA
    2 CONTINUE
      CS=COS(GA(1)/RAD)
      N=32
      XO (1)=0.
      XT(1)=XO(1)+B /2.*TGA(1)
      DZDX(1)=0.
C   XT(I)= COORDINATES OF ORIGINS OF SOURCES AT WING TIP.
C   C1,C2,C MEASURED PARALLEL TO FREESTREAM
      L=0
      YP=0.0001
      C1=CR1+YP*(TGA(2)-TGA(1))
      RLE =(RT-RR)*YP    *2./B+RR
      RTE=RLE
      RAVG=(RT+RR)/2.
      T=2.*(TT-TR)*YP/B+TR
      C=CR+YP*(TGA(4)-TGA(1))
      RU=0.
      XU=0.
      PLPI=(1.2*VOVS**2)**3.5*(6./(7.*VOVS**2-1.))**2.5
      CPO=(PLPI-1.)/(0.7*VOVS**2)
      IF(RLE.LT.0.00001) GO TO 11
C   COMBINED NEWTONIAN PERTURBATION THEORY.
      C1P=C1*CS/RLE
      TP=T/(2.*RLE)
      A1=(1.-C1P)**2+TP**2
      A2=2.*(C1P*(1.-C1P)-TP**2)
      A3=C1P**2
      XBAR=(-A2-SQRT(A2**2-4.*A1*A3))/(2.*A1)
      XU=XBAR*RLE/CS
      RBAR=SQRT(2.*XBAR-XBAR**2)
      RU=RBAR*RLE
      IF(IW.EQ.1) GO TO 151
      D1=C/2.
      D2=T/2.-RLE
      D3=RLE/CS
      D4=(D2**2+D1**2-C*D3+D3**2)/(2.*D2)
```

```
      DE=D1-XU
      ZPP=D5/SQRT(D4**2-D5**2)
      GO TO 152
151   ZPP=(T/2.-PU)/(C1-XU)
152   DZDX(1)=0.
      THM=15.
      DZDX(2)=TAN(THM/RAD)
      THI=ATAN(ZPP)*RAD
      TH1=(90.-THI)/RAD
      A1=RLE/CS
      B1=TAN(ZBP)
      F1=(CS/B1)**2
      F=F1/(1.+F1)
      XI=A1*(1.-SQRT(1.-F))
      ZI=A1*CS**2/B1*(1.-XI/A1)
C     NEWTONIAN THEORY
      THU=(90.-THM)/RAD
      CABLW=4.*RAVG*B*CPO*CS**2*(SIN(TH1)-SIN(TH1)**3/3.)
      DTH=(90.-THI)/20.
      DEL=90./RAD
      CPN(1)=CPO*CS
C     PERTURBATION THEORY
      B1=TAN(THM/RAD)
      F1=(CS/B1)**2
      F=F1/(1.+F1)
      XM=A1*(1.-SQRT(1.-F))
      ZM=A1*(1.-XM/A1)*CS**2/B1
      TH(1)=0.
      XO(1)=XM-ZM**2/CS/(RLE-XM*CS)
      XT(1)=XO(1)+B /2.*TGA(1)
      ZO(1)=0.
      XO(2)=XM
      XT(2)=XO(2)+B /2.*TGA(1)
      ZO(2)=ZM
      DZDX(3)=DZDX(2)
      TH(2)=THM
      DO 12 L=2,30
      TH(L+1)=TH(L)-1.
      IF(TH(L+1).LE.THI) GO TO 13
      THET=TH(L+1)/RAD
      DZDX(L+2)=TAN(THET)
      B1=TAN(THET)
      F1=(CS/B1)**2
      F=F1/(1.+F1)
      XO(L+1)=A1*(1.-SQRT(1.-F))
      XT(L+1)=XO(L+1)+B /2.*TGA(1)
      ZO(L+1)=A1*CS**2/B1*(1.-XO(L+1)/A1)
12    CONTINUE
      GO TO 11
13    TH(L+1)=THI
      THET=TH(L+1)/RAD
      DZDX(L+2)=TAN(THET)
      B1=TAN(THET)
      F1=(CS/B1)**2
      F=F1/(1.+F1)
```

```
      XO(L+1)=A1*(1.-SQRT(1.-F))
      XT(L+1)=XO(L+1)+B /2.*TGA(1)
      ZO(L+1)=A1*CS**2/B1*(1.-XO(L+1)/A1)
 11   IF(IW.EQ.1) GO TO 26
      A=N
      DELX=(CR-XO(L+1)-RTE/CS)/A
      DELX1=(CT-XO(L+1)-RTE/CS)/A
      N1=N+1
      DO 21 JL=2,N1
      XO(L+JL)=XO(L+JL-1)+DELX
      XT(L+JL)=XT(L+JL-1)+DELX1
      TGA(L+JL)=2.*(XT(L+JL)-XO(L+JL))/B
      ETA(L+JL)=TGA(L+JL)/BETA
      IL=L+JL
      LL=L+1
 21   CONTINUE
      XO(L+N1)=XO(L+N1)+RTE*(CR/2.-RTE/CS)/(TR/2.-RTE)
      GO TO 22
 26   XO(L+2)=CR1
      XO(L+3)=(CR-CR2)
      IF(CR2.LE.0.000001) GO TO 180
      XO(L+4)=CR+RTE*(CR2-RTE/CS)/(TR/2.-RTE)
      GO TO 181
 180  XO(L+4)=CR
 181  XT(L+2)=XO(L+2)+B/2.*TGA(2)
      XT(L+2)=XO(L+2)+B /2.*TGA(2)
      XT(L+3)=XO(L+3)+B /2.*TGA(3)
      XT(L+4)=XO(L+4)+B /2.*TGA(4)
      IL=L+4
      LL=L+1
      TGA(L+2)=TGA(2)
      TGA(L+3)=TGA(3)
      TGA(L+4)=TGA(4)
      ETA(L+2)=ETA(2)
      ETA(L+3)=ETA(3)
      ETA(L+4)=ETA(4)
 22   DO 15 J=1,LL
      TGA(J)=TGA(1)
      ETA(J)=ETA(1)
 15   CONTINUE
      Y(1)=0.0001
      YP = Y (1)
      X (1)=Y (1)*TGA(1)
      MW =M +1
      DO 3 J=1,MW
      F2=0.
      SUM21=0.
      A=M
      Y (J+1)=Y (J)+B /(2.*A)
      Y(2)=B/(2.*A)
      IF(J.EQ.M) Y(MW)=Y(MW)-0.0001
      YP = Y (J )
      IF(J.EQ.1) GO TO 154
      PLF1=(PT-RR)*Y(J-1)*2./B+RR
      PLF2=(PT-RR)*Y(J)*2./B+RR
```

```
      PLE=PLF2
      PTE=PLF
      IF(PLF1.LE.0.000001) GO TO 172
      FACTOR=PLF2/PLF1
      GO TO 173
  172 FACTOR=1.
  173 XU=XU*FACTOR
      PU=RU*FACTOR
      NI=L+1
      DO 153 I=1,NI
      XO(I)=XO(I)*FACTOR
      XT(I)=XO(I)+B/2.*TGA(1)
  153 CONTINUE
  154 YP=Y(J)
      X (J+1)=Y (J+1)*TGA(1)
      C1=CR1 +YP*(TGA(IL-2)-TGA(1))
      C2=CR2 +YP*(TGA(IL )-TGA(IL-1))
      T=2.*(TT -TR )*YP/B +TR
      C =(CR +Y (J  )*(TGA(IL )-TGA(1)))
      IF(IPRINT.NE.1) GO TO 90
      IF(MWC.GT.1) GO TO 92
      WRITE(6,91) VOVS,C
   91 FORMAT(//,50X,*PRESSURE COEFFICIENTS ON WING AT M=*,F5.3,/,60X,
     1*LOCAL CHORD=*,F6.4,*FT.*,//,40X,
     2*Y/(B/2)*,20X,*X/C*,20X,*CP*,//)
      GO TO 90
   92 WRITE(6,93) VOVS,C
   93 FORMAT(//,50X,*PRESSURE COEFFICIENTS ON CANARD AT M=*,F5.3,//,60X,
     1*LOCAL CHORD=*,F6.4,*FT.*,//,40X,
     1*Y/(B/2)*,20X,*X/C*,20X,*CP*,//)
   90 SUM2=0.
      IF(IW.EQ.1) GO TO 23
      N1=N+1+L
      N2=L+2
      D1=C/2.
      D2=T/2.-RLE
      D3=RLE/CS
      IF(D2.LE.0.0000001) GO TO 174
      D4=(D2**2+D1**2-C*D3+D3**2)/(2.*D2)
      GO TO 175
  174 D4=1000000.
  175 DO 24 JL=N2,N1
      X1=XT(JL-1)-XT(1)
      X2=X1+(XO(JL-1)-X1)*(1.-2.*Y(J)/B)
      D5=D1-X2
      DZDX(JL)=D5/SQRT(D4**2-D5**2)
   24 CONTINUE
      DZDX(N1+1)=0.
      GO TO 25
C     DZDX(I) IS SLOPE JUST UPSTREAM OF POINT I.
   23 DZDX(L+2)=(T/2.-RU)/(C1-XU)
      DZDX(L+3)=0.
      IF(C2.LE.0.0001) GO TO 170
      DZDX(L+4)=-(T/2.-RTE)/(C2-RTE/CS)
      GO TO 171
```

```
170   DZDX(L+4)=0.
171   DZDX(L+5)=0.
25    X1=X(J)-Y(J)*TGA(1)
      A=N
      XP=X (J) +XO(1)
      N1=N+1+L
      L1=L+1
      DO 29 K=1,L1
      ZPR(K)=DZDX(K)
29    CONTINUE
      IF(IW.GT.1) GO TO 27
      X1=X(J)
      GO TO 35
27    L2=L+2
      N2=N1+1
      DO 34 K=L2,N2
      ZPR(K)=DZDX(K)
34    CONTINUE
35    IF(IW.EQ.1) GO TO 70
      KLL=L+1
      E=KLL
      E=E-.1
      EE=E/2.
      KK=KLL/2
      E1=KK
      IF(EE.LE.E1) KLL=KLL+1
      K2=1
      K1=2
      IF(L.LT.2) GO TO 158
      K2=2
      IF(L.EQ.2) K2=3
      IF(IPRINT.NE.1) GO TO 158
      A1=RLE/CS
      DEL=90./RAD
      YY=Y(J)/(B/2.)
      DO 159 K=1,8
      CPN(K)=CPO*SIN(DEL)**2*CS**2
      B1=(CS/TAN(DEL))**2
      F=B1/(1.+B1)
      XP=RLE*(1.-SQRT(1.-F))
      XX=XP/C
      WRITE(6,4) YY,XX,CPN(K)
      DEL=DEL-10./RAD
159   CONTINUE
      XP=X(J)+XO(2)
158   DO 33 K=K2,N1
      IF(XP.LT.(X(J)+XO(L+1))) DX=XO(K+1)-XO(K)
      IF(K.GE.(L+1)) DX=(C-XO(L+1)-RTE/CS)/A
      SUM1=0.
      CALL CP3DW
      CP(K,J)=-2.*SUM1
      IF(CP(K,J).LT.0.) GO TO 75
      IF(CP(K,J).GT.CPO) CP(K,J)=CPO
      GO TO 76
75    IF(ABS(CP(K,J)).GT.CPO) CP(K,J)=-CPO
```

```
76    X2=XP-X(J)
      IF(RLE.LT.0.00001) GO TO 132
      IF(K.GE.KLL) GO TO 132
      A11=SQRT(1.+ZPR(K)**2)
      SID=ZPR(K)/A11
      CPN(K)=CPO*SID**2
      AB=CP(2,J)-CPN(2)
      IF(K.EQ.1) GO TO 52
      IF(AB.GT.0.) GO TO 130
      ABB=CP(K,J)-CPN(K)
      IF(CP(K,J).LT.0.) GO TO 131
      IF(ABB.LT.0.) GO TO 52
131   IF(K1.EQ.1) GO TO 132
      AK=K
      ALK=L
      AKL=AK/ALK
      TH1=(90.-THM+AKL*(THM-THI))/RAD
      CABLW=4.*RAVG*B*CPO*CS**2*(SIN(TH1)-SIN(TH1)**3/3.)
      KLL=K
      K1=1
      F=K
      E=F-.1
      EE=E/2.
      KK=K/2
      E1=KK
      IF(EE.GE.E1) GO TO 132
      KLL=KLL-1
      GO TO 132
130   ABB=CP(K,J)-CPN(K)
      IF(ABB.GT.0.) GO TO 52
      IF(K1.EQ.1) GO TO 132
      K1=1
      KLL=K
      AK=K
      ALK=L
      AKL=AK/ALK
      TH1=(90.-THM+AKL*(THM-THI))/RAD
      CABLW=4.*RAVG*B*CPO*CS**2*(SIN(TH1)-SIN(TH1)**3/3.)
      F=K
      E=E-.1
      EE=E/2.
      KK=K/2
      E1=KK
      IF(EE.GE.E1) GO TO 132
      KLL=KLL-1
132   F=K
      E=F-.1
      EE=E/2.
      KK=K/2
      E1=KK
      IF(EE.GE.E1) GO TO 53
      FHALF=CP(K,J)*(ZPR(K)+ZPR(K+1))/2.
      GO TO 52
53    IF(K.GT.KLL) GO TO 54
      FT=CP(KLL,J)*ZPR(KLL+1)
```

```
      F=FI
      GO TO 52
54    FI=CP(K,J)*(ZPP(K)+ZPP(K+1))/2.
      SUM2=SUM2+DX/3.*(F+4.*FHALF+FI)
      F=FI
52    X1=XT(K)-B*TGA(1)/2.
      XP=X(J)+XO(K)+2.*Y(J)*(X1-XO(K))/B+DX+DX/7.
      IF(XP.GT.(X(J)+C-RLE/CS)) XP=X(J)+C-RLE/CS
150   IF(IPRINT.NE.1) GO TO 33
      YY=Y(J)/(B/2.)
      XX=X2/C
      IF(K.GE.KLL) GO TO 160
      IF(K1.EQ.1) GO TO 160
      WRITE(6,4) YY,XX,CPN(K)
      GO TO 33
160   WRITE(6,4) YY,XX,CP(K,J)
4     FORMAT(41X,F6.3,20X,F7.4,18X,F6.3)
 33   CONTINUE
      GO TO 71
70    CONTINUE
      K1=2
      KLL=L+2
      IF(L.LT.2) GO TO 85
      CPN(2)=CPO*CS**2*0.9698
      IF(IPRINT.NE.1) GO TO 156
      A1=RLE/CS
      DEL=90./RAD
      YY=Y(J)/(B/2.)
      DO 155 K=1,8
      CPN(K)=CPO*SIN(DEL)**2*CS**2
      B1=(CS/TAN(DEL))**2
      F=B1/(1.+B1)
      XP=RLE*(1.-SQRT(1.-F))
      XX=XP/C
      WRITE(6,4) YY,XX,CPN(K)
      DEL=DEL-10./RAD
155   CONTINUE
156   DO 83 K=1,L
      XWW=X(J)+XC(K)
      XW(K)=XWW
      DX=XO(K+1)-XO(K)
      XP=XW(K)
      SUM1=0.
      CALL CP3DW
      CP(K,J)=-2.*SUM1
      A11=SQRT(1.+DZDX(K+1)**2)
      SID=DZDX(K+1)/A11
      CPN(K)=CPO*SID**2
      IF(K.EQ.1) GO TO 83
      IF(IPRINT.NE.1) GO TO 101
      YY=Y(J)/(B/2.)
      X2=XP-X(J)
      XX=X2/C
      IF(K.GE.KLL) GO TO 157
      IF(K1.EQ.1) GO TO 157
```

```
      WRITE(6,4) YY,XX,CPN(K)
      GO TO 101
157   WRITE(6,4) YY,XX,CP(K,J)
101   AP=CP(2,J)-CPN(2)
      IF(AP.GT.0.) GO TO 84
      APP=CP(K,J)-CPN(K)
      IF(CP(K,J).LT.0.) GO TO 86
      IF(APP.LT.0.) GO TO 83
86    IF(K1.EQ.1) GO TO 83
      AK=K
      ALK=L
      AKL=AK/ALK
      TH1=(90.-THM+AKL*(THM-THI))/RAD
      CABLW=4.*RAVG*B*CPO*CS**2*(SIN(TH1)-SIN(TH1)**3/3.)
      KLL=K
      K1=1
      GO TO 83
84    APB=CP(K,J)-CPN(K)
      IF(ABB.GT.0.) GO TO 83
      IF(K1.EQ.1) GO TO 83
      K1=1
      KLL=K
      AK=K
      ALK=L
      AKL=AK/ALK
      TH1=(90.-THM+AKL*(THM-THI))/RAD
      CABLW=4.*RAVG*B*CPO*CS**2*(SIN(TH1)-SIN(TH1)**3/3.)
83    CONTINUE
85    L1=L+3
      XWW=X(J)+XO(L+1)
      XW(L+1)=XWW
      ZPP(L+1)=D7DX(L+1)
      XP=XW(L+1)-0.00001
      SUM1=0.
      CALL CP3DW
      CP(L+1,J)=-2.*SUM1
      K=L+1
      IF(CP(L+1,J).GT.CPO) CP(K,J)=CPO
      IF(IPRINT.NE.1) GO TO 102
      YY=Y(J)/(B/2.)
      X2=XP-X(J)
      XX=X2/C
      WRITE (6,4)YY,XX,CP(K,J)
102   CONTINUE
      XW(L+2)=XWW
      ZPP(L+2)=D7DX(L+2)
      XP=XW(L+2)+0.00001
      SUM1=0.
      CALL CP3DW
      CP(L+2,J)=-2.*SUM1
      K=L+2
      IF(CP(L+2,J).GT.CPO) CP(K,J)=CPO
      IF(IPRINT.NE.1) GO TO 103
      YY=Y(J)/(B/2.)
      X2=XP-X(J)
```

```
      YY=X2/C
      WRITE (6,4)YY,XX,CP(K,J)
 103  CONTINUE
      X12=XO(L+2)+Y(J)*TGA(L+2)
      X13=XO(L+3)+Y(J)*TGA(L+3)
      X14=CR-RTE/CS+Y(J)*TGA(L+4)
      XX=X13-X12-0.00001
      IF(XX.LE.0.0) GO TO 60
      N11=N/4
      AA=N11
      N12=N11+2+L
      DX=(X12-XWW)/AA
      LN=2
      GO TO 61
 60   N11=N/2
      LN=1
      AA=N11
      DX=(X12-XWW)/AA
      N12=N11+2+L
 61   DO 28 K=L1,N12
      XW(K)=XW(K-1)+DX
      IF(K.EQ.N12) XW(N12)=XW(N12)-0.00001
      XP=XW(K)
      SUM1=0.
      CALL CP3DW
      CP(K,J)=-2.*SUM1
      IF(IPRINT.NE.1) GO TO 104
      YY=Y(J)/(B/2.)
      X2=XP-X(J)
      XX=X2/C
      WRITE (6,4)YY,XX,CP(K,J)
 104  CONTINUE
      ZPR(K)=DZDX(L+2)
 28   CONTINUE
      IF(ABS(CP(N12,J)).GT.CPO) CP(N12,J)=-CPO
      JK=N12
      JI=KLL
      LK=1
      IF(Y(J).GT.0.001) GO TO 80
      CP(L+2,J)=CP(L+3,J)
      CP(N12,J)=CP(N12-1,J)
 80   CALL SIMPH(CP,XW,ZPR,JI,JK,J,LK)
      IF(LN.EQ.1) GO TO 62
      DX=(X13-XW(N12))/(2.*AA)
      N13=N12+2
      N14=3*(N11+1)+L
      XW(N12+1)=XW(N12)+0.00001
      ZPR(N12+1)=0.
      XP=XW(N12+1)+0.00001
      SUM1=0.
      CALL CP3DW
      CP(N12+1,J)=-2.*SUM1
      K=N12+1
      IF(IPRINT.NE.1) GO TO 105
      YY=Y(J)/(B/2.)
```

```
      X2=XP-X(J)
      XX=X2/C
      WRITE (6,4)YY,XX,CP(K,J)
105   CONTINUE
      IF(ABS(CP(N12+1,J)).GT.CPO) CP(N12+1,J)=-CPO
      DO 64 K=N13,N14
      XW(K)=XW(K-1)+DX
      IF(K.EQ.N14) XW(N14)=XW(N14)-0.00001
      ZPR(K)=0.
      XP=XW(K)
      SUM1=0.
      CALL CP3DW
      CP(K,J)=-2.*SUM1
      IF(ABS(CP(K,J)).GE.CPO) CP(K,J)=-CPO
      IF(IPRINT.NE.1) GO TO 106
      YY=Y(J)/(B/2.)
      X2=XP-X(J)
      XX=X2/C
      WRITE (6,4)YY,XX,CP(K,J)
106   CONTINUE
64    CONTINUE
      ZPR(N14+1)=DZDX(L+4)
      XW(N14+1)=XW(N14)+0.00001
      XP=XW(N14+1)+0.00001
      SUM1=0.
      CALL CP3DW
      CP(N14+1,J)=-2.*SUM1
      K=N14+1
      IF(IPRINT.NE.1) GO TO 107
      YY=Y(J)/(B/2.)
      X2=XP-X(J)
      XX=X2/C
      WRITE (6,4)YY,XX,CP(K,J)
107   CONTINUE
      IF(ABS(CP(N14+1,J)).GT.CPO) CP(N14+1,J)=-CPO
      DX=(X14-X13)/AA
      N14=N14+2
      N15=4*(N11+1)+L
      DO 65 K=N14,N15
      XW(K)=XW(K-1)+DX
      IF(K.EQ.N15) XW(N15)=XW(N15)-0.00001
      XP=XW(K)
      SUM1=0.
      CALL CP3DW
      CP(K,J)=-2.*SUM1
      IF(IPRINT.NE.1) GO TO 108
      YY=Y(J)/(B/2.)
      X2=XP-X(J)
      XX=X2/C
      WRITE (6,4)YY,XX,CP(K,J)
108   CONTINUE
      ZPR(K)=DZDX(L+4)
65    CONTINUE
      JT=N14-1
      JK=N15
```

```
      LK=1
      IF(Y(J).GT.0.001) GO TO 81
      CP(N14+1,J)=CP(N14+2,J)
      CP(N15,J)=CP(N15-1,J)
   81 CALL SIMPW(CP,XW,ZPR,JI,JK,J,LK)
      XW(N15+1)=XW(N15)+0.00001
      XP=XW(N15)+0.00001
      SUM1=0.
      CALL CP3DW
      CP(N15+1,J)=-2.*SUM1
      ZPR(N15+1)=DZDX(L+5)
      N1=N15+1
      GO TO 71
   62 XW(N12+1)=XW(N12)+0.00001
      XP=XW(N12+1)+0.00001
      SUM1=0.
      CALL CP3DW
      CP(N12+1,J)=-2.*SUM1
      IF(CP(N12+1,J).LT.0.) GO TO 77
      IF(CP(N12+1,J).GT.CPO) CP(N12+1,J)=CPO
      GO TO 78
   77 IF(ABS(CP(N12+1,J)).GT.CPO) CP(N12+1,J)=-CPO
   78 CONTINUE
      K=N12+1
      IF(IPRINT.NE.1) GO TO 109
      YY=Y(J)/(B/2.)
      X2=XP-X(J)
      XX=X2/C
      WRITE (6,4)YY,XX,CP(K,J)
  109 CONTINUE
      ZPR(N12+1)=DZDX(L+4)
      DX=(X14-X13)/AA
      N13=N12+2
      N15=2*(N11+1)+1+L
      DO 67 K=N13,N15
      XW(K)=XW(K-1)+DX
      ZPR(K)=DZDX(L+4)
      IF(K.EQ.N15) XW(N15)=XW(N15)-0.00001
      XP=XW(K)
      SUM1=0.
      CALL CP3DW
      CP(K,J)=-2.*SUM1
      IF(IPRINT.NE.1) GO TO 110
      YY=Y(J)/(B/2.)
      X2=XP-X(J)
      XX=X2/C
      WRITE (6,4)YY,XX,CP(K,J)
  110 CONTINUE
   67 CONTINUE
      IF(CP(N15,J).GT.CPO) CP(N15,J)=CPO
   66 XW(N15+1)=XW(N15)+0.00001
      XP=XW(N15)+0.00001
      SUM1=0.
      CALL CP3DW
      CP(N15+1,J)=-2.*SUM1
```

```
      K=N1F+1
      IF(IPRINT.NE.1) GO TO 111
      YY=Y(J)/(B/2.)
      X2=XP-X(J)
      XX=X2/C
      WRITE (6,4)YY,XX,CP(K,J)
  111 CONTINUE
      ZPR(N15+1)=DZDX(L+5)
      N1=N15+1
      JT=N13-1
      JK=N15
      LK=2
      IF(Y(J).GT.0.001) GO TO 82
      CP(N12+1,J)=CP(N12+2,J)
      CP(N15,J)=CP(N15-1,J)
   82 CALL SIMPW(CP,XW,ZPR,JT,JK,J,LK)
   71 CDS=2.*SUM2/C
      CDS1=CDS*C**3/(T*CR)/T
      CDSC=CDS*C
      E2=J
      E2=E2-.1
      E3=E2/2.
      JJ=J/2
      E4=JJ
      IF(E3.GE.E4) GO TO 55
      FHALFY=CDSC
      GO TO 3
   55 IF(J.GT.1) GO TO 56
      FIY=CDSC
      FY=FIY
      GO TO 3
   56 FIY=CDSC
      DY=Y(J)-Y(J-1)
      SUM3=SUM3+DY/3.*(FY+4.*FHALFY+FIY)
      FY=FIY
    3 CONTINUE
   97 RETURN
      END
```

```
      SUBROUTINE WTINT(RW,SW,RT,ST,ART,CLAW,   ,CRW,XLCPT,XL     ,ELTA,A
     1LAMT,XH,XKWB,XKWB1,CLTVA,ALPHA)
      SW=RW+.5*BW
      ST=.5*RT+RT
C     AT PRESENT SLENDER BODY VALUE IS USED F    F
      PI=3.14159
      F=PI/4.*(SW-RW)+RW
    3 FACT=F
      ALPHO=ALPHA/57.29578
      H=(XLCPT-XLEFF-CRW)*SIN(ALPHO)-(CRW-XH)*SIN(DELTA)
      FI=F*RT**2/(F**2+H**2)
      HI=H*RT**2/(F**2+H**2)
      SUM=0.
      DO 10 I=1,4
      GO TO (4,5,6,7),I
    5 F=-F
      GO TO 4
    6 F=FI
      H=HI
      GO TO 4
    7 F=-FI
      H=HI
    4 C8=(ST-RT*ALAMT)
      C9=1.-ALAMT
      C10=F-ST
      C11=F-RT
      C12=(C8-F*C9)/(2.*(ST-RT))*ALOG((H**2+C10**2)/(H**2+C11**2))
      C13=C9/(ST-RT)
      C14=(ST-RT)+H*ATAN(C10/H)-H*ATAN(C11/H)
      FUNC=C12-C13*C14
      IF(I.EQ.2.OR.I.EQ.3) FUNC=-FUNC
      SUM=SUM+FUNC
   10 CONTINUE
      FW=FACT
      XI=2./(1.+ALAMT)*SUM
   29 CONTINUE
      CLTV=(CLAW*CLAT*(XKWB*ALPHO+XKWB1*DELTA)*XI*(ST-RT))/(6.28*ART*(FW
     1-RW))
      CLTVA=CLTV
      RETURN
      END
```